THE

NATURAL AND MORBID CHANGES

OF

THE HUMAN EYE,

AND THEIR TREATMENT.

BY

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PREFACE.

Soon after having become connected with Guy's Hospital I felt that much time and unnecessary labour might be saved both to the students and to myself by a book embracing the practical portions of modern ophthalmology.

The advances made within the last twelve years in ophthalmology, and recorded in essays, periodicals, &c., in this country and abroad, by far exceed in practical importance those made in any other branch of medical science.

I shall consider this book to have attained its object if to the student it renders ophthalmology intelligible and useful, and if to the practitioner it affords a faithful record of the present state of this branch of medical science.

The subdivision of the matter contained in the book into chapters according to the structures involved has been adopted more because such is usually the case with books of this kind than because it is the most practical or physiological classification. One based upon the functions of the different structures of the eye, or one which uses the terms employed by patients to express the nature of the disturbance of their vision, &c., as the key to facilitate diagnosis, would perhaps have been preferable. Great care, however, has been taken in the construction of an index, so as to embody all those words and sentences which may assist the reader, from the statements of his patient, to discover the nature and treatment of the individual case.

No references to works on ophthalmological subjects are given in the different chapters, neither are the names mentioned of those whose merit it is to have advantageously influenced the state of ophthalmology by invention of instruments or by original researches.

The matter contained in this book being however in great part derived from the labours of others, and adapted by myself to the requirements of men in general practice, it is necessary to mention here the books which should be read

by those who wish for more ample information on the subjects treated, and to state the nature of the more important innovations in ophthalmology.

Among periodicals should be consulted: The Royal London Ophthalmic Hospital Reports, and Journal of Ophthalmic Medicine and Surgery; and The Ophthalmic Review, a Quarterly Journal of Ophthalmic Surgery and Science (edited by Zachariah Laurence of London, and Thomas Windsor of Manchester). Among continental publications must be mentioned :—A periodical published by Professor Donders, of Utrecht (Výfde jaarlýksch Verslag, betrekkelijk de Verpfleging en het onderwijs in het nederlandsch Gasthuis voor Ooglijders); The Archives of Ophthalmology, published in Berlin, by Prof. v. Graefe, Donders, and Arlt (Archiv für Ophthalmologie, herausgegeben von Prof. F. Arlt in Wien, Prof. F. C. Donders in Utrecht, und Prof. A. v. Graefe in Berlin); and the Annales d'Oculistique, published in Brussels.

No ophthalmological work, however, more deserves the attention of the medical man in general practice, as well as that of the oculist, than the one translated by W. D. Moore, M.D., Dublin, &c., and published by the New Sydenham Society, London, 1864, "On the Anomalies of Accommodation and Refraction of the Eye; with a Preliminary Essay on Physiological Dioptrics by F. C. Donders, M.D., Professor of Physiology and Ophthalmology in the University of Utrecht."

The reader will find in this book not only a clear exposition of the hitherto obscure relations between refraction and accommodation of the eye in health, but also a most lucid description of the anomalies of refraction and accommodation and their treatment. The contents of the chapters in this book which treat of anomalies of refraction and accommodation are, with few exceptions, to be regarded as expositions of the work of Prof. Donders.

I have to thank Mr Bowman for the opportunities afforded to me at the Eye Infirmary, Moorfields, of examining during the last four years an unusually large number of patients suffering from anomalies of accommodation and refraction. Assisted by the material so obtained, and by the work of Prof. Donders, I have endeavoured to give such clearness and shortness to the chapters treating on these subjects as to bring them within the grasp of those whose medical duties prevent their entering into the details of dioptrics, &c. A clear explanation of the subjects treated in the book of Prof. Donders is given by Dr Soelberg Wells in a work on long, short, and weak sight, &c., published by John Churchill, New Burlington Street, London.

Among the new instruments which have most assisted in the promotion of our knowledge of ophthalmology, must be mentioned the ophthalmoscope and the various instruments for ascertaining the positions and curvatures of the light-refracting surfaces of the eye. An account of the latter instruments, and specially the results obtained with them, is given in the book of Prof. Donders mentioned above.

The ophthalmoscope was invented in 1851 by Helmholz, at that time Professor of Physiology at Königsberg, in Prussia. An excellent account of the changes which the instrument has undergone, with numerous engravings representing the various kinds of ophthalmoscopes, is given by Mr Carter in a

work entitled "The Ophthalmoscope, translated from the German of Dr Adolf Zander by Robert Brudenell Carter, F.R.C.S., Eng. (Exam.), with Notes and Additions by the Translator. London, Robert Hardwicke, 192, Piccadilly. 1864."

The ophthalmoscope in its simplified form has come into general use, and has proved indispensable to the oculist as well as to the medical man in general practice. It not only enables us to view the retina, optic disc, &c., in health and disease, but often also affords the earliest means of recognizing the presence of general morbid changes, such as albuminuria, syphilis, cerebral tumours, &c. A knowledge of the mode of using the ophthalmoscope may be acquired within a few hours, and richly repays the philosopher as well as the physician.

Among the numerous works upon the changes of the retina, choroid, &c., which have appeared since the invention of this instrument, must be mentioned, "A Practical Treatise on the Use of the Ophthalmoscope, &c., by J. W. Hulke, F.R.C.S., published by John Churchill, New Burlington Street, London," and the "Atlas of Ophthalmoscopic Drawings, with Text, by Dr Liebreich, of Paris."

I have not entered into any criticism in the course of the book as regards the medical, surgical, or optical treatment of affections of the eye. Having for more than twelve years followed the practice at the different Eye Infirmaries of this metropolis, and for several years that of continental Hospitals, I have preferred stating the treatment which I should recommend to be adopted.

I shall in this place, however, take the opportunity of making a few remarks upon the more important changes which ophthalmology has undergone in reference to diagnosis, and treatment.

A service of great importance has been rendered to ophthalmology by Mr Jonathan Hutchinson's researches on infantile syphilis. These have shown a very frequent form of *corneitis*, hitherto described as strumous, to be one of the numerous symptoms of inherited syphilis.

The treatment of affections of the lachrymal passages has been rendered much more simple and successful by Mr Bowman's operation of slitting open the lachrymal puncta and canaliculi, and by his adopting a series of large probes and other instruments in the treatment of obstructions and strictures of these passages. The operations as well as the necessary instruments have come into general use.

The operation for strabismus. The two methods of operating most frequently adopted are that termed the subconjunctival method, and that by which an incision is made into the conjunctiva over the tendon, the latter drawn out of the wound and divided close to the sclerotic, and the conjunctival incision united again by a suture. The latter mode of operating, known as v. Graefe's method, is generally practised on the continent, and has found advocates in this country. Mr Critchett was the first to operate by the subconjunctival method at the Eye Infirmary, Moorfields, where this mode of operating is maintained by most of the surgeons. More practice is required to operate by the subconjunctival method, and I have found that beginners obtain better results, and succeed with greater facility, by the other mode of operating, though I prefer the subcon-

junctival method. The treatment of strabismus (convergent as well as divergent) by the application of atropia together with the use of proper spectacles has of late been adopted in many cases with great success, since Prof. Donders has shown the connection between strabismus and its cause, viz. the anomaly in shape of the eyeball.

Operations for the removal of cataract. Instead of the usual mode of removing soft cataract by absorption, many surgeons adopt the operation of linear extraction, or remove the cataract by suction (an operation which was first extensively practised by Mr Pridgin Teale, Jun., of Leeds), as quicker methods of restoring vision. Both methods, if the cataract is fluid or very soft, may with safety be employed by any one. If the cataract is glutinous much experience and manual dexterity are required to avoid the complications arising from attempts at rapid removal.

The innovations, introduced for the removal of hard cataract, refer chiefly to the application of chloroform, to the performance of iridectomy, and to the extraction of the cataract by artificial means, and through a smaller or differently-shaped section. As regards the question of chloroform, many differences of opinion exist, and I shall confine myself to stating that for the last four years I have been in the habit of giving chloroform to every patient with cataract, whatever his general health or age may have been, if from his manner or from his behaviour while examining the eye, or from existing increased tension of the eye, I had any doubt as to the complete passiveness of the patient, or of his eyes, during the operation. Only in one case out of nearly 200 did hæmorrhage occur into the vitreous chamber after the operation, during vomiting, and in this case I had doubts whether the bandage applied had not been disturbed.

As regards the performance of iridectomy, the result of the experience of those who operate by extraction, without giving chloroform, is, that the risks of losing vitreous are more numerous; and that it is preferable not to perform iridectomy, but to wait, and to remove prolapse of the iris by iridectomy whenever it shows itself after the operation. For removal of cataract with the scoop, iridectomy is indispensable. Though vision is less acute, even if the iridectomy "is made upwards," than when the pupil is circular, yet it is, as a rule, sufficiently good to admit of the usual occupation of the patient. A comparison of the results obtained, when removing cataract by simple extraction, with those when removing it "under chloroform" with the scoop or by other artificial means, combining with the operation an iridectomy, shows, according to statistics published by others, that a smaller number of patients obtain useful vision by the operation of simple extraction.

This statement, I believe, holds good only if the operator has obtained equal dexterity in both modes of operating. More practice, and a more thorough knowledge of the physical properties of the parts within the eye are required for the success of the scoop operation. The complications which may present themselves during certain stages of this operation are more numerous.

The operation of iridectomy. This operation was introduced into practice in 1856 by Professor v. Graefe, of Berlin. Its influence upon the morbidly-

increased tension of the eyeball led him to adopt it in glaucoma. The operation has become generally established. Its modus operandi is not yet understood, but it has proved the remedy by which the largest number of patients suffering from glaucoma are relieved.

The operation of division of the ciliary muscle was first practised by Mr Hancock, and performed by him and others for glaucoma, as well as for other morbid changes not accompanied by or not caused by undue tension of the eyeball.

The operation of iridesis, or iridodesis, introduced by Mr Critchett, is preferred by some to the old operation for artificial pupil.

The operation of excision of the eyeball in its present simplified form was first brought into practice at the Eye Infirmary, Moorfields, by Mr Critchett.

The acuteness of vision and the state of refraction and accommodation of the eye are, as a rule, ascertained by the aid of test types, i. e. by a series of letters of different definite sizes. The most perfect of the kind are those published by Dr Snellen (Dr H. Snellen. "Test Types for the determination of the Acuteness of Vision. New Edition. Printed by P. W. Van de Weyer, Utrecht, Holland, 1866").

Though in the course of this book it is shown how to make use of common letters, when ascertaining the acuteness of vision, &c., it is very desirable that those who are engaged in the study of ophthalmology should procure Dr Snellen's Test types.

Wherever in the following chapters test types are alluded to, Dr Snellen's test types are to be understood.

Messrs Smith and Beck, Opticians, 31, Cornhill, London, at present supply the patients attending at Guy's Hospital with spectacles. For the use of the oculist, as well as for that of the medical man in general practice, they have manufactured boxes containing a series of lenses (cylindrical and spherical) and other optical contrivances, which are indispensable to those who engage in the optical treatment of anomalies of vision.

In most continental works the decimal system is employed for the expression of linear measure. In this system the unit of length is called a mètre, and expresses the ten-millionth part of the meridian arc passing through Paris, and extending from the north pole to the equator.

A mètre is equal to 39.3707904 English inches. Hence we have a decimètre, equal to 3.93708 ; a centimètre, equal to .393708 ; a millimètre, equal to .0393708. By those who wish to convert metrical into the present English linear measure, the following mode may be adopted : Let it be required to express fifteen millimètres ($=15^{mm}$) in English inches. Since one millimètre = .0393708 English inches, 15 millimètres = 15 × .0393708 English inches = .590563, or = $\frac{59}{100}$, or $\frac{6}{10}$, or $\frac{3}{5}$ inch nearly.

To convert English inches into French millimètres: Since one mètre = 39,37079 inches, therefore one inch = $\frac{1}{39,37079}$ mètre = .02539954 mètre = 25.39954 millimètres = 25.4 millimètres nearly. Ex. How many millimètres are equivalent to $3\frac{3}{4}$ inches? $3\frac{3}{4}$ inches = $3\frac{3}{4} \times 25.39954$ = 95.24827 millimètres. If we assume 1 inch = 25.4 millimètres, then $3\frac{3}{4}$ inches = $3\frac{3}{4} \times 25.4$, or 95.25 millimètres.

The sign $'$ is used for foot, $''$ for inch, and $'''$ for line (or $\frac{1}{12}$ of an inch). Thus distances of $5'$, $5''$, $5'''$, signify distances of five feet, five inches, and five lines. The same sign ($'$) as for the notation of foot, and the sign $''$ for the notation of inch, is used in other books, the former for angular minutes, and the latter for angular seconds. It is therefore better (and it is mostly practised in the different chapters) to write the denominational word after the number—thus, instead of $5'$ $5''$ $5'''$, we write 5 feet, 5 inches, 5 lines.

In the course of each chapter those abbreviations are given which are generally accepted by modern ophthalmologists. To save trouble to the reader, however, the words which are represented by the abbreviations have been printed in full. It was thought necessary to give these abbreviations, since in many essays, &c., on ophthalmological subjects, they are made use of without explanation.

Six plates of chromolithographs representing portions of the interior of the eye in health and disease, and four plates, one with lithographs of surgical instruments, and three representing portions of retina, &c., are published in a separate volume. This has been done partly to facilitate the use of the plates while reading the book, and partly to admit of the purchase of the plates in a separate form.

I conclude with the expression of my sincere thanks to those whose valuable advice and assistance have been so freely rendered me in the preparation of the following chapters for publication. My thanks are especially due to my friend and colleague, Mr Durham.

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CHAPTER I.

THE ORBIT.

ANATOMICAL AND GENERAL REMARKS.

The bony walls of the orbit are thin; the outer and the upper are the strongest, and the inner is the weakest. The roof or upper wall is slightly arched. It is formed by the orbital or horizontal plate of the frontal bone and lesser wing of the Sphenoid, and supports the corresponding anterior lobe of the brain. The floor, or lower wall, descends from before backwards. It is formed by the orbital or horizontal plate of the superior maxillary bone, (which also constitutes the roof of the antrum,) the orbital surface of the malar, and the orbital process of the palate bone. The outer wall passes inwards and backwards, and separates the orbit from the temporal fossa. The inner runs directly backwards, parallel to that of the fellow orbit, and separates the orbit from the ethmoidal cells. The axis of one orbit, if prolonged towards the brain, crosses that of the other at the sella turcica.

Part of the outer and upper angle of the pyramid, formed by the walls of the orbit, is occupied by the Sphenoidal or upper orbital fissure. The periosteum of this fissure and that of the optic foramen are continuous with the dura mater. The Spheno-maxillary or lower orbital fissure is longer and wider than the Sphenoidal, and leads into the temporal fossa.

In the space between the eyeball and the orbit we find connective tissue, fat, muscles, blood-vessels, &c. The optic foramen is about an inch and a half distant from the inner angle of the margin of the orbit (i. e.

the portion of the margin situated behind the inner canthus). The third, fourth, and sixth nerves (the motor nerves), and the ophthalmic division of the fifth nerve pass through the Sphenoidal fissure, while the optic nerve passes through the optic foramen. *The blood-vessels* of the eyeball and those of the orbit freely anastomose with those of the cranium, and of the face, and the nasal cavities. The infraorbital artery, coming from the internal maxillary branch of the external carotid, and sending branches to the inferior rectus muscle, to the adjoining periosteum, and to the lower lid, runs, together with its corresponding vein and nerve, in a groove and canal in the lower wall of the orbit. The other arteries of the orbit come from the ophthalmic artery (a branch of the internal carotid). The ophthalmic artery passes through the optic foramen by the outer and lower side of the optic nerve; and within the orbit, and at a short distance from the optic foramen, it crosses over the surface of the nerve. Here it sends off the retinal artery, or arteria centralis retinæ, and the arteries for the eyeball (the two long posterior, and from four to six short posterior ciliary arteries). The retinal artery passes into the optic nerve, and runs among its fibres to the retina. The ciliary arteries pass near the upper surface of the nerve to and through the sclerotic. Having crossed the optic nerve, the ophthalmic artery runs near the inner wall of the orbit, sending off branches to the muscles; these branches again give off the ten or fourteen short ciliary arteries which pass into the eyeball through the anterior portion of the sclerotic.

The veins of the retina and most of those of the choroid and of the orbit empty themselves into the cerebral ophthalmic vein, which passes through the Sphenoidal fissure, and joins the cavernous sinus. The two sinuses communicate with each other by means of the circular sinus, and through the petrosal sinuses their blood is conveyed to the internal jugular veins. Some of the veins of the orbit and of the choroid (ciliary region) anastomose with the infra orbital vein.

DEVELOPMENT.

About the end of the second and during the third month of intra-uterine life the shape of head and face is already well marked. About the middle of the fourth month the nose is much depressed and the forehead very prominent, large, and high. About the middle of the second month the first trace of an orbital bone is found, as a small fork-shaped spicule, which situated near the upper margin of the sclerotic aperture partially embraces the optic nerve. This spicule of bone continues to grow upwards and forwards. About the end of the fourth month a reddish, gelatinous substance appears at the apex of the orbit, intervening between it and the eyeball. This represents the fat of the orbit. It increases most rapidly about the sixth month.

CONGENITAL ANOMALIES.

Absence of one or both orbits, together with absence of the lachrymal gland, has been observed; also absence of portions of one or both orbits, the eyeballs being imperfect, or their places being occupied by connective tissue. The orbits sometimes assume abnormal directions, or are placed too near to each other, or stand unusually far apart.

PROTRUSION OF THE EYEBALL.

(Exophthalmos=protrusion of one or both eyes through—generally acute—inflammation within the orbit, or of the orbit and eyeball. Hydrophthalmos=protrusion of one or both eyes through distension of the tunics of the eyeball, especially by fluid, and without real change of place of the enlarged eye. Ophthalmoptosis=protrusion through paralysis or paresis of the muscles. Luxation of the eye=sudden protrusion through injury. Evulsion of the eye=sudden protrusion by injury; the eyeball being more or less torn away from its appendages.)

Protrusion of the eye, if it interferes with the functions of the retina or optic nerve, gives rise to impairment or loss of vision. Anomalies in the function of the fifth nerve (pain, anæsthesia), or paresis or paralysis from changes in the third, fourth, or sixth nerve, may arise with or without derangements of the circulation and nutrition of the eye.

If adjoining cavities are implicated, an additional series of symptoms appear, which may be due to tumours in these cavities.

Rapidity of appearance. Protrusion occurs suddenly during and after hæmorrhage behind the eyeball, and in some cases of aneurism. In a few cases of aneurism it has appeared gradually, but has increased rapidly.

It has occurred within a few days after simultaneous paralysis of the third, fourth, and sixth nerves. Slight pressure upon the eyeball made it disappear.

A rapid succession of the signs of tumour in the orbit, with outward inflammation, may lead us to suspect the presence of an abscess, especially if fluctuation is felt somewhere between the eyeball and the margin of the orbit.

Of tumours which are accompanied by gradual protrusion, the bony tumours are the slowest, the cancerous ones the most rapid, in their progress.

Mobility of the eyeball, and increase and direction of the protrusion.

Increase of the protrusion indicates an increase of the morbid changes behind the eye, or their extension towards it. If situated in front of the equator of the eyeball, they may spread between it and the walls of the orbit, push forwards the conjunctiva and the lids, impair the movements of the eyeball, and yet hardly displace it; while if situated behind the equator protrusion always appears.

The eyeball becomes displaced outwards and downwards, or outwards and upwards, through changes in the frontal sinuses. Through enlargement of the lachrymal gland it may be displaced inwards and downwards. The direction of the displacement of the eyeball varies if caused by changes at the apex of the orbit, according to which wall of that cavity is most implicated; if, e. g., it be pushed downwards and forwards, we suspect the apex of the orbit and its upper wall to be most at fault.

The amount of protrusion is not proportionate to the size of the tumour, &c., which may cause it. A tumour may fill out the adjoining cavities, and encroach but little upon the orbit. The protrusion, when caused by disturbances in the circulation, increases on stooping, or increases and decreases spontaneously, or may be arrested or otherwise influenced by compressing the carotid artery of the corresponding side. The protrusion may be increased by the action of the orbicularis muscle—the expanded fibres of which, when closing the lids, may press upon the protruding tissue between the margin of the orbit and the eyeball, and through this upon the eyeball behind its equator.

The more the eye is pushed forwards the more its mobility is decreased. Its movements may be impaired in one or two directions, particularly if the cause of protrusion is confined to one side of the orbit, as in tumours, caries, &c. They may be impeded in all directions equally, as for instance, in struma, and in hypertrophy of the orbital tissue. A mobility in all directions, however impeded, shows that the eyeball is not adherent to the walls of the orbit. The movements may remain impeded in all directions, or may be destroyed; or the eyeball may become fixed in a certain position after the protrusion has subsided.

Changes of the protruded eye and of its appendages.—The lids readily become flaccid if expanded over a large or protruding eyeball, and by accident or during manipulation the margin of either lid may slip back over the eye. A bent probe passed beneath the displaced lid readily succeeds in lifting it forwards. Œdema, drooping and redness of the lids, and œdema, chemosis, and enlargement of the vessels of the conjunctiva occur in rapid or considerable protrusion. Vascularity of the conjunctiva in one particular part may be a guide as to the situation of the cause. As soon as the protrusion is so considerable that the cornea is no longer protected, the destruction of the eye may be expected. Anæsthesia of the cornea frequently occurs even in moderate degrees of protrusion. The corneæ and conjunctivæ of young people may remain exposed to the air, &c., without injury, for a longer time than those of the aged. The state of nutrition and health of the cornea previous to the protrusion materially influence its power of resistance to exposure. Cases of struma and of cancer have occurred in which both the protruding corneæ suppurated or sloughed. In a case of hæmorrhage behind the eyeball in a young man,

the cornea sloughed within thirty-six hours after the commencement of the extreme protrusion. The cornea having become perforated, the contents of the eye may escape, and the eyeball shrink; or the suppuration may extend, and ophthalmitis ensue. In some cases extreme protrusion may exist for weeks during an inflammation of the deeper parts of the orbit, and yet, the protrusion subsiding, the eye may resume its functions, or, though apparently intact, may remain amblyopic or amaurotic. In other cases, ophthalmitis may appear even during moderate protrusion.

VISION.—Double vision is complained of when protrusion of an otherwise healthy eye occurs rapidly, especially if associated with lateral displacement. In every case we should inquire for double vision, and also ask whether it came on suddenly, whether it has existed for a long time, and whether it is present in all directions, or in what direction of the eye it is most perceived. For instance, we suspect morbid changes at the roof of the orbit if, on looking upwards, the patient observes double vision with differences in the height and parallelism of objects. In slowly progressing protrusion double vision remains unobserved, or vision may have become too much impaired to make it perceptible.

An eye may protrude so much as to render it difficult for the lids to close over it, and yet for months the patient may be able to read well, and have otherwise what he terms good sight. In other cases of but slight protrusion, sight may be lost. In a case of aneurism of one ophthalmic artery, vision was lost long after the recovery from protrusion.

Patients complaining of "a black veil coming over the sight," or of "only seeing half an object," frequently suffer from displacement of part of the retina, an accident which accompanies most intraocular, and some of the extra-ocular tumours.

A little boy, suffering from medullary cancer in one orbit, lost the previously good sight of both eyes in one night. His complaint to the nurse the next morning was, that "the night was so long." A small cancerous deposit was found after death implicating both optic nerves at the optic foramina.

Visions of bright colours, flashes of light, falling of stars, are frequently complained of in congestion of, or pressure upon, a healthy optic nerve, for instance, in the course of melanotic tumours of the orbit.

Pain and cerebral symptoms.—Absence of pain is a favourable symptom. Pain felt when pressing upon the eyeball or upon the tumour generally indicates periostitis. Pain in the head at the back of the eyeball, coming on suddenly, has been observed in aneurisms, and in periostitis, at the apex of the orbit. Headache occurs frequently in protrusion from periostitis (especially if of syphilitic origin), or from impediments to the circulation of blood in the larger vessels.

Inflammation originating in the tissues of the orbit may extend into the brain, and cause meningitis, &c. Convulsions, epileptic fits, hemiplegia, impairment of the mental faculties, and paralysis of the first, second, and third nerves, have occurred when suppuration has extended from the orbit to the base of the brain. Brain symptoms during inflammation in the orbit and without paralysis of the first, second, or third nerves, indicate the probability of the presence of pus between the dura mater and the bones near the roof of the orbit, or in the anterior lobe of the brain. Loss of appetite, vomiting, increase of heat, increased frequency of pulse, shivering, sleeplessness, delirium, may occur after operations for protrusion, and indicate disturbances at the base of the brain. In a case recently operated on in Guy's Hospital (for enlargement of the right frontal sinus) with protrusion, hemiplegia and delirium appeared on the second day, and subsided a week after the operation, the patient recovering completely.

Causes of protrusion in general.—Protrusion of both eyes is frequently observed in persons suffering from palpitations of the heart, with enlargement of the thyroid gland (struma). Accumulation of blood in the vessels of the orbit is the probable cause. It has been observed in feeble, stout persons, generally females, from an undue accumulation of fat in the orbits (as found after death), with weakness of the muscles of the eyeball.

Protrusion during acute inflammation of both eyeballs, or of the tissue of both orbits, is very rare; so also is cancer in both eyeballs or orbits simultaneously. More frequently we observe protrusion of both eyes as a complication of hydrophthalmia.

Protrusion of one eye, from inflammation within the orbit, has occurred during scarlatina, measles, variola, puerperal fever, and similar diseases, and most frequently during recovery. Also after injuries, during erysipelas, phlebitis, glanders, and tuberculosis, from inflammation of the lachrymal gland, from abscesses formed in adjoining cavities, for instance in the cranium, or the frontal sinuses, and perforating a wall of the orbit. Acute inflammation of the soft parts of the orbit, or of its bones, or of the eyeball, constitute, as a rule, the immediate causes of the protrusion. Every ophthalmitis, especially if it occur quickly, as may happen after extraction of cataract, causes in itself protrusion by implicating the soft parts of the orbit.

Considerable protrusion, without external inflammation, may be caused by tumours; for instance, bony new growths, cysts, or aneurisms; by paralysis of the third, fourth, or sixth nerve; by hæmorrhage behind the eyeball, occurring spontaneously, or after an illness; by accumulation of serum between the eyeball and Tenon's capsule (in a case of this kind it increased on stooping and then occasioned pain; the eye was subsequently

excised); by enlargement of the nasal cavities, of the frontal sinuses, or of the antrum.

General remarks on treatment.—Great similarity often exists between the external symptoms of protrusion from different causes; and, in many instances, the line of treatment remains uncertain until we have reached the cause—tumour, &c.,—with the knife. This is particularly the case if inflammation of the soft parts of the orbit, or of the eyelid, complicate deep-seated tumours. In every case of protrusion we compare the thickness, position, &c., of the margins of the two orbits, and, if possible, pass the finger into the fornix of the conjunctiva between the walls of the orbit and the eyeball, to ascertain the elasticity, consistence, fluctuation, &c., of a deep-seated cause of protrusion.

By directing the patient to turn the eye in various directions to bring into view the curvature of the sclerotic, we ascertain the shape of the eyeball, and how much of the protrusion is due to enlargement of the eye, and also whether the sclerotic is adherent to whatever may cause the protrusion, and whether the functions of the recti or obliqui muscles are impaired.

Other means of diagnosis are auscultation of the margin of the orbit, ophthalmoscopic examination, and a careful scrutiny of the cavities adjoining the orbit.

The operation of removal of a tumour is indicated if the tumour increases in spite of medical treatment; if the eyeball or the brain is in danger; if a permanent disfigurement is imminent, especially if the eye can be saved.

Cases of removal of large tumours from the orbit, in which vision has been preserved, are numerous. Whether the eye be lost or not, we adopt that mode of operating which, with complete removal, gives the best result as regards personal appearance. The operation is the more difficult the longer it is postponed, if the tumour grows rapidly. Tumours which grow slowly, and without pain, which are well-defined, where the eyelids are not implicated, and where the patient's health is good, are, as a rule, of a non-malignant character. The size, situation, and especially the nature of the tumour, whether cancer or not, influence our prognosis. If the nature of the tumour is not known, and its complete removal necessary, then for want of space we may be obliged to remove the eyeball. The removal of bony tumours may take hours. Cases of this kind have occurred in which the attempt at removal had to be discontinued on account of the difficulties met with during the operation. Before proceeding to the removal, an exploring trocar may be passed into the tumour, along that wall of the orbit which gives the easiest access to it, unless there be symptoms of aneurism.

For the removal of bony tumours, we require the instruments used in other parts of the body for similar purposes, as gouges, chisels, &c., of

different sizes. It may be necessary to keep the patient under the influence of chloroform for an hour or more. If we determine upon the removal of the eyeball, this part of the operation should be done first; the tumour may thus be rendered more accessible.

The incision through the skin and soft parts is carried over the most prominent part of the tumour, and parallel with the margin of the orbit. A large tumour may require a second incision, meeting the first at right angles. The surface of the tumour, once freely exposed, if of bony nature, is seized with the forceps, and sometimes may be broken off from its attachment. With the saw, the gouges, chisels, &c., we may have to work round its base to detach it. Diseased bone near the tumour should be removed. Bruising of the eyeball must be avoided as carefully as possible. A soft tumour or a cyst must be freely exposed, in order to reach the base or pedicle.

After the operation we facilitate free escape of pus, &c., and adhere to the general rules for the treatment of inflammation of the orbit.

No secondary operations for the correction of changes in the position of the eyelids or eyeball, &c., need be performed until the effects of the first operation (swelling, redness, tenderness, discharge, &c.) have completely subsided.

For further particulars see the treatment of the special causes of protrusion.

TUMOURS OF THE ORBIT, OR OF THE EYEBALL, OR OF BOTH.

Tumours may cause protrusion of the eyeball, whether they be situated within the eye, or in the orbit, or in the cavities adjoining the latter (the frontal sinuses, the antrum, and the nasal cavities). They may appear simultaneously in several of these localities; or they may secondarily cause inflammation, &c., of the soft parts within the orbit.

Cancer.—The growth, as in other parts of the body, consists of a variable quantity of connective tissue, blood-vessels, or interstices filled with blood, brown or black pigment in varying proportion, and cancer cells. Portions of the growth may be of a brown colour ("mixed melanotic and medullary cancer"), or have the consistence and somewhat the colour of brain substance ("pure medullary cancer"), while other portions are of fibrous hardness. Sudden transitions of colour or consistence may appear in some parts, gradual transitions in others. In the melanotic form the cells and fibres are loaded with brownish or black pigment granules, and with amorphous black matter. The cancer cells of cancerous growths in the orbit or eyeball differ in no respect from those found elsewhere.

The medullary and melanotic forms of cancer have been found primarily in all parts of the orbit and eyeball, e. g., upon the cornea, upon the outer surface of the sclerotic, near the optic nerve,—attached to the inner

surface of the sclerotic, and passing through the choroid and retina into the vitreous chamber,—and in the ciliary muscle.

In the retina the medullary, and in the choroid the melanotic, forms seem to occur primarily most frequently. (See the preparations at the College of Surgeons, at Guy's Hospital, and at the Eye Infirmary, Moorfields.)

Cancer may appear simultaneously in different parts of the orbit and eyeball. It may cause inflammation of the adjoining tissues; or it may extend into them by infiltration, and thus frequently appear as a "tumour." It seems especially prone to extend along the course of the veins. It may fill the eyeball (sclerotic), destroying all its contents, long before appearing elsewhere; or it may show itself upon the outer surface of the sclerotic soon after its appearance within the eye. In the Museum of the College of Surgeons, and in that of the Eye Infirmary, Moorfields, are preparations from the same eye of cancer adhering to and surrounding the greater part of the eyeball without invading its interior.

Increased vascularity of the conjunctiva, displacement of the iris, paralysis of the pupil, swelling with loss of transparency of the lens, enlargement of the ciliary veins, and swelling of the sclerotic with bulging of the latter, may precede the extension of cancer from the interior of the eye, while in other cases hardly any irritation occurs during extensive development of cancerous tissue within and around the eyeball.

Destruction of the iris, suppuration, or sloughing of the cornea, with protrusion of cancer, occur but rarely; this may, however, happen, from whatever part of the interior of the eye the cancer may have originated.

Cancer in the choroid is most frequently of the melanotic kind, and originates in the part of the choroid occupied by the large veins (vasa vorticosa). Its favourite seat is the region of the yellow spot. It may appear as a defined tumour, or in the form of diffuse infiltration, or as both. Traces of the elastic lamina generally covered with colloid globules, swollen, roundish (changed hexagonal) cells, or hexagonal cells with enlarged nuclei, and with only a few or no pigment granules, may be found on the surface of the new growth, while its base rests among the stellate pigment cells of the choroid.

The secondary changes usually found in the other tunics of the eye are, destruction of the vitreous substance (by pressure), and partial or total displacement of the retina.

Every cancer which springs from the sclerotic or choroid, and projects into the vitreous chamber within the area of the retina, causes changes in the position of the latter. Thus the retina may become adherent to the tumour, or its curvature may undergo alteration in consequence of its being pushed into the vitreous chamber; or it may be completely detached from

the choroid by an accumulation of fluid. This fluid, which is always highly albuminous, may be clear or mixed with blood, cancer cells, or pus; its effusion is supposed by some to be caused by pressure of the tumour upon the veins of the choroid.

A very small tumour may be accompanied by displacement of the entire retina by fluid, while a large tumour may merely detach that part which passes over its surface. The same applies to the vitreous substance, which does not disappear in proportion to the size of the tumour, nor to the rapidity of its growth. A small tumour, together with fluid effused between the choroid and retina, may cause all "the vitreous" to disappear, while some "vitreous" may remain by the side of a tumour which occupies the greater part of the interior of the eyeball.

Displacement of the retina may precede for some time, and frequently masks, the appearance of a tumour in the choroid. Complete displacement of the retina, with increase of tension, indicates the probable existence of a tumour within the eyeball. In such cases, a part of the retina is in apposition with the lens, and is thence reflected towards its insertion along the ora serrata. This indicates great pressure upon the outer surface of the retina by the fluid between it and the choroid.

Other secondary changes are, destruction of the retina, cataract, iritis, sloughing of the cornea, &c., &c. Such changes may not appear until years after the loss of vision. In one case eight years elapsed. In the case of a patient aged fifty, "five years ago a black cloud was observed rising from the lower part of the eye, and obscuring the upper halves of objects;" displacement of the retina was thus indicated: sight was entirely lost in three months after the first appearance of the cloud. The eye was not otherwise troublesome until five months ago, when it began to shrink (instead of becoming perforated, as is usual in cancer) and to become painful. It was excised. The interior was found occupied by a hard black (melanotic) mass, firmly adherent to the sclerotic, and consisting of a dense net-work of fibrous tissue, loaded with brown pigment granules, and amorphous black pigment. Traces of choroid, and a "chalky" crystalline lens were found, but neither vitreous nor retina. Such a course of melanotic growth in the choroid is very unusual.

Cancer in the retina and optic nerve.—In one case the growth appeared primarily in the retina, in the shape of greyish-white and opaque nodules, some of which were ill-defined, and seemed to originate in the layer of the retina adjoining the optic-nerve fibres. The outer surface of the retina was not adherent to the choroid.

In several cases cancer has been observed primarily in the optic nerve and by preference at the sclerotic aperture, and at the optic foramen. The medullary form, with a moderate amount of connective tissue, is the most frequent. It may give rise to great protrusion without involving the

organ itself; or it may encroach considerably upon the brain, without sensibly disturbing the cerebral functions.

Vision.—The accounts given by patients suffering from intra-ocular tumours as to loss or impairment of vision vary.

Many find accidentally that "the sight of the eye is lost," or are led to examine the state of vision by some peculiarity in the appearance of the eye. Some state that "the eye has been blind for years, and has only lately commenced to be troublesome." Muscæ and flashes of light are rarely observed. A mist intervening between objects and the eye, and gradually becoming thicker, is often complained of. Some at first notice that objects can be perceived only when held in certain positions. The perception of a black cloud, which seems to rise "from the lower part of the eye," and obscures the upper halves of objects, is very common; the cloud rises higher and higher, and finally destroys sight. This symptom must be referred to displacement of the retina, preceding or accompanying the growth of a "tumour."

Diagnosis and course.—If the lens is transparent, we may often with the Ophthalmoscope obtain a view of the tumour. In a patient aged twenty-six a tumour (medullary cancer) projecting from the upper equatorial region of the tunics of the eye into the vitreous chamber, presented the following appearances:—close behind the lens was seen a rounded, well-defined substance about the size of a large pea, and of a waxy-white colour. It had no independent movement. Its summit stood about opposite the posterior pole of the lens, and both sides and summit were overrun by blood-vessels belonging to the retina. Some coming from the optic disc could be traced round the sides of the tumour, while others disappearing behind it reappeared on the summit. Grey and opaque flocculi were observed floating in the vitreous chamber near the tumour. From the transparency of the retina and choroid immediately around the base, it was inferred that these tunics were in their normal positions at that part. The eye and the tumour are preserved in the Museum of the Eye Infirmary, Moorfields.

Displaced portions of retina, if opaque, mask a tumour of the choroid or sclerotic. In this case, an increase of tension of the eye, attacks of ophthalmia with pain, paralysis, and dilatation of the pupil, with displacement of the lens forward, make the presence of intra-ocular tumour very probable. We must not neglect to ascertain the mobility of the eye and the curvature of the sclerotic.

The diagnosis is more difficult if the lens is opaque, and vision impaired or lost. The mode in which vision has been lost, the general health of the patient, the family history, and such points as are taken into consideration in cases of tumour elsewhere, have to be inquired into. If there is no pain and no perception of light, we may be obliged to wait

before expressing an opinion. Melanotic cancer, when appearing upon the outer surface of the sclerotic, may be mistaken for staphyloma of the sclerotic, unless the Ophthalmoscope be used, when the semi-transparency of the staphyloma will decide the question.

Cancer, as a rule, increases much more slowly when confined to the interior of the eyeball. Ten years or more may elapse in grown persons from the first symptoms of cancer in the eye to its becoming fatal. Ill health, more than anything else, seems to favour its increase. Pain is rarely absent throughout its course; paroxysms may occur at any time. Attacks of "ophthalmia" as a rule occur after vision is lost; they have a glaucomatous character, being accompanied by increase of tension. After a certain stage is reached, the neighbouring glands may become infiltrated.

Patients may die from the effects of fever, from general emaciation, from loss of blood or pus, or from the effects of cancer in other organs.

Treatment.—Respecting the advisability of excision of the eyeball or of removal of a cancerous growth from the orbit, opinions vary. Some think that if the general health is supported and no operation performed the patient lives longer than if operated upon. The experience of those who advocate an operation is, that melanotic cancer returns sooner than any other form, and that cancer originating in the retina or optic nerve, though the orbit be not implicated, is likely to return sooner than when springing from other parts of the eye or orbit.

An operation is thought not advisable (*a*) if the total removal of the cancer be impossible (the eyeball immovable and adherent to the orbit); (*b*) if the glands near it be swollen (this swelling being referable to the cancer); (*c*) if the cancer have existed for a considerable time, and have lately been increasing rapidly.

The increase of pain and tension has in some cases been temporarily arrested by iridectomy.

Complications of cataract with cancer are not uncommon. We must be guided in the diagnosis by careful examination of the sensibility of the different parts of the retina, of the tension of the eye, and by the state of health preceding the appearance of cataract. The presence of cancer renders the removal of the cataract useless.

Excision of the eyeball, or tumour, if decided upon, should be performed as soon as possible. If the patient's general health is good, especially if he is young and if the cancer is confined to the interior of the eye, there is the greatest probability that the return of the cancer will be tardy.

STRUMOUS DEPOSIT.

Choroiditis hyperplastica.—A yellowish and opaque, sometimes brilliant

metallic reflection from behind the pupil, most frequently observed in children, is by many considered as characteristic of cancer. Displaced retina alone, however, with or without chalky changes in the vitreous substance, lymph close behind the lens, and particularly the so-called strumous deposit, are often found to be the cause of this appearance.

Whatever may be the substance which gives rise to the yellow reflection, both in cancer and strumous deposit we observe blood-vessels. These vessels differ in size and arrangement from retinal blood-vessels, which latter, if the retina is displaced by fluid, accompany the movements of the floating folds of the displaced retina.

The diagnosis between strumous deposit and cancerous growth remains uncertain as long as the former is on the increase. Both develope spontaneously, and may occur at any age. In this country the strumous deposit is observed more often in fair than in dark-complexioned children.

The yellow substance behind the pupil, if covered by retina, appears smooth, but its surface assumes a flocculent vascular aspect when the retina is destroyed. It may, if much pigment be present, have an almost black colour, the grey or yellow and opaque portions only shining through in places.

While growing, it consists, microscopically, of elongated fusiform or round nucleated cells with intercellular substance traversed by blood-vessels. The cells rapidly increase in number, and are frequently mixed with pus cells. When shrinking, an amorphous smeary substance, with a few nuclei and cells, fat, cholesterine, pigment granules, and varying proportions of connective tissue are found. As this deposit increases, it destroys the vitreous substance, and pushes the lens forwards. The iris becomes paralyzed, and the pupil extremely dilated.

In many cases the lens becomes opaque, and the iris and ciliary processes infiltrated.

Portions of sclerotic adjoining the parts within the eye which are undergoing change may become vascular, swollen, bulging, and infiltrated. Suppuration of the cornea, or profuse purulent discharge from the interior of the eye, may take place.

The occurrence of pain seems chiefly to depend upon an increase of the tension of the eye. There may be no pain if the "strumous deposit" increase slowly.

Strumous deposit may be spontaneously arrested at any stage. Such arrest most frequently takes place after the vitreous substance is destroyed. It establishes the difference of the disease from cancerous growth. The progress of strumous deposit is slower in grown persons than in children. It may appear in both eyes.

Its arrest frequently shows itself by gradual shrinking of the eyeball,

with decrease of tension. The eye becomes flaccid, and finally reduced to a small irregular mass.

In the case of a boy aged ten months, in which the strumous growth sprang from the retina, the following changes were observed before and after excision, and after death. The child, apparently in perfect health, was brought to the hospital on account of a "yellow reflection from the pupil of the right eye." It had been observed occasionally two months previously, and had lately become very obvious. There was no pain, and apparently no perception of light; the pupil was slightly dilated, and acted only in concert with the fellow pupil. A brilliant yellow, opaque, non-vascular substance was visible close behind the lens. Three weeks later small blood-vessels appeared on the surface of the substance. After another three weeks the eye protruded slightly; it was equally movable in all directions, somewhat enlarged, very hard, and exceedingly painful when touched. The anterior chamber was small, the transparent lens nearly touching the cornea; the pupil was fixed and irregularly dilated, the iris discoloured and reduced to a mere rim. The surface of the yellowish substance situated behind the lens was somewhat obscured by greyish and opaque shreds, which had a limited floating movement in front of it. The child became feverish, cerebral symptoms supervened, and death occurred a fortnight later.

Dissection.—The skull was not opened. Some purulent fluid was seen oozing from the cranial cavity through both optic foramina. The left eye was healthy. In the right orbit, along the sheath of the optic nerve small pea-sized tumours, resembling enlarged glands, were loosely imbedded in the fat. They were about eight in number. In the right eye the aqueous humour was slightly yellowish. The lens was transparent and nearly in contact with the cornea. The vitreous substance within the area of the ciliary processes appeared yellowish but otherwise healthy. A yellowish white opaque substance of the size and shape of a large bean was found attached to the optic disc and adjoining retina, and projecting into the vitreous chamber. Between it and the vitreous substance there was some slightly turbid fluid in which numerous greyish-white opaque shreds were floating. The retina all round the tumour was displaced and thrown into folds, turbid fluid occupying the space between it and the choroid and the tumour. A greyish-white substance, in some places one-tenth of an inch thick, intervened between the choroid and sclerotic, causing firm adhesion of these membranes to each other.

With the naked eye no vessels containing blood could be seen in the tumour, which was easily broken away from its attachment. The fibres of the optic nerve disappeared in it. Its interior was softening. It consisted of cells of the size of pus cells and larger, filled with granular

matter; among these were pus cells, and numerous capillary vessels sprinkled with fat globules and traces of connective tissue.

The outer and inner surfaces of the swollen and infiltrated choroid were thickly sprinkled with plexuses of capillaries resembling blood spots. Cells similar to those in the tumour were found in sundry infiltrated portions of the choroid and sclerotic, and in the little tumours along the sheath of the optic nerve.

Treatment.—The removal of the eye is indicated in those cases only in which the pain or suppuration threaten to exhaust the patient. General tonic treatment and local frictions with mercurial ointment are adopted with benefit. In several cases of undoubted syphilitic character arrest and decrease of the deposit have been effected by anti-syphilitic treatment. In some cases vision has been restored.

Pneumonia and meningitis are the usual causes of death.

BONY, FIBROUS, SARCOMATOUS, AND FATTY TUMOURS.

Exostoses, of which the ivory exostosis is the most frequent, *enchondromata*, *fibro-calcareous tumours*, and *fibrous tumours*, with spicula of bone, have been met with. Bony tumours most frequently originate from the inner wall of the orbit, and thus may be mistaken for enlargement of the ethmoidal cells or frontal sinuses.

Fibrous and sarcomatous tumours spring from the periosteum of the orbit, by one or several pedicles. Fatty tumours are sometimes congenital.

Of the fibro-calcareous species a specimen is in the Museum of the Eye Infirmary, Moorfields. It sprang from the inner and upper wall of the orbit near the margin, and consisted of fibrous tissue, containing large irregular spaces filled with blood, and lacunæ which were occupied by calcareous matter. It grew from the periosteum, inwards, i. e. new material was deposited from the periosteum, and the latter displaced outwards.

CYSTS.

Cysts most frequently occur at some part of the inner wall of the orbit. They may become as large as hens' eggs.

Some are multilocular, with strong fibrous walls, and are barely attached to the orbit. They contain reddish serum, with cholesterine or dark brownish fluid (decomposed blood), or flakes of a greyish and opaque cheesy-looking substance (sebaceous cysts). The latter originate, as a rule, in the skin of the eyelids.

Hydatids (the cysticercus and echinococcus) and *hæmorrhage* into the orbit, are the most frequent causes of cysts in this region.

A bursa is occasionally found in front of, or behind the insertion of

the levator palpebræ muscle. This may become distended, and form a cyst called a hygroma, which may give rise to protrusion of the eye.

Cysts may occur in the course of morbid changes of the lachrymal gland.

A case of *polypus* commencing in the nose, perforating the orbit, and thence passing into the brain, has been observed. Death was caused by meningitis.

Treatment.—If by an exploratory puncture or by any symptoms we have ascertained the existence of a cyst or cystic tumour, we should as the shortest, and, in the end, least hazardous treatment, attempt its complete removal. In one case, in which a seton was introduced through the upper lid and through the cyst, the eye resumed its normal position at the end of ten months. Ten years afterwards the protrusion reappeared, and was arrested by another seton.

Excision of the front wall of the cyst has been followed by hæmorrhage into its interior, and by increased protrusion of the eyeball. Rest, leeches, and cold fomentations have been required to check the protrusion.

In one case, in which part of the wall of the cyst had been removed, a second portion had to be excised a year later. Delirium and much suppuration followed. Recovery took place three months after the second operation. Some advise the application of a paste made with chloride of zinc, spread upon leather, to those parts of the cyst or morbid deposit not removed by the operation.

PULSATING TUMOURS OF THE ORBIT.

The causes of pulsating tumours of the orbit usually met with have been (1) true or diffused aneurism of the ophthalmic or some other artery within the orbit; (2) impediments to the return of the blood from the ophthalmic vein. Of these the true aneurism of the ophthalmic artery is the least frequent.

The tumour as a rule appears during middle or advanced age, rarely spontaneously, or from bodily exertion, but frequently sooner or later after an injury. The pulsation, the protrusion of the eyeball, and other symptoms in the larger number of cases appear suddenly. The patient complains of a beating or throbbing in the eye or over the eyebrow, which increases on stooping. The pulsation is communicated to the eyeball, and a loud blowing murmur, or a bruit synchronous with the systole of the heart, is heard by placing the ear upon the (upper) margin of the orbit.

In two cases of injury all the symptoms of aneurism behind the eyeball were present, and yet none was found in either case after death. The symptoms were caused, in the one case by partial compression of the internal carotid artery against the sphenoid, in consequence of swelling of

the bone about the cavernous sinus. The cavernous, transverse, circular, and petrosal sinuses were inflamed and filled with pus.

In the other case the ophthalmic vein at its junction with the cavernous sinus was found to be closed by fibrin and pus.

In these cases the momentary increase of the quantity of blood in the orbit during the pulsation of the ophthalmic artery, and the resistance offered by the walls of the orbit, together with the impeded return of blood through the veins, seem to explain the impulse imparted to the eyeball.

Treatment.—Ligature of the common carotid artery of the side corresponding to the pulsating tumour proved successful in eleven out of twenty-one cases in which it was performed. Two cases were cured by digital pressure upon the common carotid. This mode of treatment should be fairly tried in every case before proceeding to any operation. In several of the unsuccessful cases the pulsating tumours remained stationary. In one the tumour returned after a few weeks; and in one, several small aneurisms appeared after the large one had ceased to pulsate.

NÆVUS "Erectile Tumour."

Nævus has been observed at different depths in the orbit, most frequently in the neighbourhood of the eyelids. In one case the tumour was found on dissection to be enclosed in a "capsule" of connective tissue which might have been removed by operation.

A nævus when forming a tumour in the orbit is soft to the touch, and increases in size and tension during crying or straining. It is rarely met with in grown people.

Varicose veins situated near the margin of the orbit and increasing in size on stooping have sometimes assumed the appearance of tumours.

Treatment.—Several cases of nævus have been treated successfully by injection. Instances of sudden death after this operation have however occurred within the last three years. The pure tincture of perchloride of iron was used. The children died immediately after the injection.

Ligature of the nævus succeeded perfectly, in one case, and arrested the further increase of the nævus in another case.

The least dangerous but slowest treatment consists in drawing silk threads saturated with tincture of perchloride of iron through the nævus. Care should be taken that the threads are thick, and that they close the openings made by the needle. The number used must depend upon the size of the nævus. The object is to set up adhesive inflammation in different parts of the growth. The threads may be removed at the end of a week, or as soon as slight suppuration has set in around them. Other threads may have to be inserted if the nævus has not disappeared after all inflammation caused by the first set has ceased.

SPONTANEOUS HÆMORRHAGE INTO THE ORBIT.

This form of hæmorrhage generally comes on suddenly, e. g. after illness, or after great fatigue in weakly persons, or after an injury, without any brain symptoms, with or without paralysis of all the muscles of the eye. It causes protrusion of the eye, without signs of aneurism. The protrusion remains stationary if the blood become encysted; if not, a fortnight or a month will suffice for recovery.

The general treatment must depend upon the patient's health. In persons with a tendency to hæmorrhage a recurrence of the protrusion may happen. Locally several leeches, or a small blister to the temple, or frictions with mild mercurial ointment, and gentle pressure upon the closed eyelids, with a bandage, may be tried.

Protrusion caused by hæmorrhage behind the eye during operations in or near the orbit requires the immediate closure of the eyelids by a tightly-applied bandage, if necessary with wire sutures, until the protrusion is subsiding.

PROTRUSION OF THE EYEBALL, WITH PALPITATION OF THE HEART, AND ENLARGEMENT OF THE THYROID GLAND, "EXOPHTHALMIC GOÎTRE."

The nature of this form of protrusion, and the changes in the heart, arteries, thyroid gland, &c., with which it is associated, are not well understood. In some cases the thyroid gland is not enlarged, in others the heart appears healthy; in few only one eye is found protruding. In most cases no organic disease of the heart is found at the commencement of the protrusion.

As primary causes may be enumerated,—Atheromatous changes in the coats of the arteries followed by hypertrophy of the heart; impediments to the return of blood and subsequent enlargement of the thyroid gland: and as secondary causes of the protrusion,—Distension of the veins of the orbit with an œdematous condition of the tissue within the orbit.

On post-mortem examination of a case which occurred lately, neither hypertrophy of the orbital tissue, nor increase of fat, nor enlargement of the lachrymal gland was found. The thyroid gland was enlarged, the left ventricle of the heart hypertrophied, and atheromatous changes were observed in the arteries.

The youngest patient affected with this form of protrusion was ten years old. The patients, as a rule, suffer either from chlorosis or from morbid action of the heart, or from both. In females the enlargement of the thyroid gland is more marked than in males.

The course of the disease is very chronic; it seems to be more acute in

males. The first symptom generally observed is an abnormal action of the heart; the pulse is increased in frequency from eighty to one hundred or one hundred and fifty, and the impulse of the heart is strong, and accompanied by palpitations. A bruit is heard with the systole in some cases. A sensation of tightness and of difficulty in breathing frequently follows. The enlargement of the thyroid gland and the protrusion of one or more generally of both eyes occur later. The protrusion is preceded by insufficient relaxation of the levator palpebræ muscle. The protrusion has been observed in about sixteen per cent. of the cases. In six per cent. the sight of both eyes was lost.

The degree of protrusion varies. One or both eyes may be protruded straight forwards, and their movements equally impaired, in all directions. One eye, generally the right, may be more displaced than the other. The displacement may be so considerable as to give rise to difficulty in closing the lids, or to more or less complete exposure of the cornea. In the latter case yellow opaque dry scales become accumulated upon the opaque and continually exposed portion.

Ophthalmitis may occur even while the corneæ are still protected. The chemosis and varicose condition of the conjunctival blood-vessels vary in degree.

Treatment.—In weak and old persons the hope of recovery is slight. The greater the frequency of the pulse the worse the prognosis. Rest, milk diet, the local application of ice, bathing the eyes with iced water, and such general treatment as the constitutional symptoms of the case may suggest, should be prescribed if the pulse is above one hundred.

Preparations of iron are of great service, and may be continued for months or years if the pulse is only from eighty to one hundred.

In one case the administration of secale cornutum in ten-grain doses four times daily for two months, was attended by complete recovery.

Locally, frictions with iodine ointment into the skin over the thyroid gland may be ordered if the latter is enlarged. This treatment is expected to diminish the fulness of the orbit, and thereby the protrusion of the eye.

In cases of impaired mobility of the eyelids, the palpebral aperture has been narrowed by operation. By this means the cornea becomes more protected, increased pressure is exercised by the lids upon the eyeball, and the protrusion is rendered less conspicuous. The operation must be performed on both sides, and symmetrically, in order to enable the patient to close the lids readily.

If the surface of the cornea, from continued exposure, has become opaque, or covered with scales, the temporary complete closure of the lids is indicated, until, under general treatment, the protrusion has diminished, so as to admit of the lids readily protecting the cornea.

Much benefit is derived from the application of a bandage, causing slight pressure upon the closed lids during sleep.

PROTRUSION THROUGH ENLARGEMENT OF THE FRONTAL SINUSES.

The upper and inner portions of each orbit anteriorly form part of the floor of the corresponding frontal sinuses. Large sinuses are generally accompanied by great prominence of the superciliary eminences. The sinuses are lined by mucous membrane which is continuous with that of the nasal cavities. Their abnormal distension by mucus, &c., may be suspected, 1st, if we find the eyeball displaced outwards and slightly downwards with a greater prominence of the anterior wall of the sinus (i. e. of the superciliary eminence) : or, 2nd, if we find a diffuse enlargement of the inner and upper portion of the orbit anteriorly, compared with that of the healthy side ; such enlargement may be accompanied by a more or less prominent swelling below the brow, of varying consistence (elastic or firm) and shape (smooth or uneven), with defined or undefined base. The skin may be unchanged and moveable, or red and adherent to the swelling. There may be one or several fistulous openings. The swelling generally extends backwards along the roof and inner wall of the orbit. There is hardly ever any pain.

Tumours attached to this part of the orbit, or circumscribed inflammation of the bone and periosteum, may be mistaken for enlargement of the sinuses. In periostitis the great pain, especially at night or when the part is touched, together with the relief afforded by medical treatment, may assist in the diagnosis of the case.

Most commonly the sinuses are enlarged by accumulation of thick transparent or partly opaque mucus or by muco-pus, rarely by pus ; this may be fœtid and mixed with blood. The mucus or muco-pus is of the same kind as that which is secreted during catarrh by the mucous membrane of the nose. In rare instances, solid bony tumours, exostoses, and polypi attached to the walls of the sinuses, or encroaching from adjoining cavities, have been found.

Injuries (blows on the face) causing obstruction of the passages between the sinuses and the nasal cavities are the usual cause. Such has been found to be the case in eight out of nine instances. The enlargement may exist for a few weeks only, and then become perceptible, or it may continue for from four to six years without causing much inconvenience. The patient's attention is generally attracted when the enlargement displaces the eyeball, impedes its movements, and, as sometimes happens, causes diplopia, or some other derangement of vision.

Treatment.—Little benefit is derived from medicinal treatment. It should, however, be tried. In a case in which some insect had become

lodged in one of the sinuses, and had caused irritation of the mucous membrane, the smoking of cigars impregnated with arsenic was found beneficial. A careful inquiry into the cause, the course, and the extent of the swelling and the inconvenience arising from it determines the line of treatment.

Surgical interference is required if the swelling increases rapidly, and impairment of vision becomes marked, or cerebral symptoms appear. If removal of the enlargement is decided upon, an incision is made below the supraorbital ridge over the most prominent part, avoiding the supraorbital vessels, &c. The incision must vary in length according to the size of the swelling; and should be at once carried through the soft parts, down to the bone,—the blade of the knife being held parallel to the wall of the orbit, along which we wish to reach the swelling; we thus avoid wounding the eyeball. The most prominent part of the swelling only is exposed, and the point of the knife is thrust into it. If we find a solid tumour, we expose its entire surface freely, and remove it with the forceps, chisel, or gouge, either by breaking it off from its attachment, or by working round its base, and removing it as well as we can. The thinness of the walls of the orbit must be borne in mind.

If we find enlargement of the frontal sinuses by mucus, &c., an aperture cut into the most prominent part will enable us to expose and clear out the contents of the cavity with the finger or sponge, and to ascertain the relation of the enlarged sinus to the brain, to the eye, &c. In the cavity we may find rough portions of bone (from fracture or disease), or the expanded smooth mucous membrane only.

After having removed the mucus, one finger is introduced into the corresponding nasal cavity up to the nearest part of the enlarged sinus; a bistoury is then passed through the opening made in the expanded bony walls of the sinus to the spot corresponding to that touched by the finger introduced into the nose, and an incision is made through this part of the wall of the sinus down upon the finger, so as to establish a large opening of communication between the nose and the sinus. A "seton" (a strong cord of twisted silver wire, or a stout silk thread) is carried through this opening, and the end projecting from the nasal cavity is tied to the one which projects from the incision in the skin. The loop thus formed is moved by the patient, several times daily, with a view of establishing a permanent opening between the sinus and the nasal cavity. The patient has to keep in bed as long as there is headache or much redness and swelling round the incision. The position of his head must be such as to facilitate the escape of matter. Cold water dressing is applied over the wound.

The patient should be shown how to press upon the swelling over the "eye," so as to cause the discharge to escape readily through the external wound, and, if possible, also through the opening made into the nose, and

how to move the seton to and fro, or to introduce some blunt instrument into the nose, and into the opening which leads from it into the sinus.

Four weeks after the operation the seton may be removed. In some cases it has been left in for several months.

This operation for removing enlargement of the frontal sinuses has succeeded in all cases. In one instance, the silver wire gave rise to much irritation, and to cerebral symptoms, and was therefore withdrawn. However the daily introduction (by the patient) of a smooth piece of ivory (the handle of a cataract knife) through the nasal cavity, into the opening, finally succeeded in restoring the normal dimensions of the sinus and its communication with the nose. In this case, the distension of the (right) frontal sinus was very great, extending towards the brain, and as far back as the apex of the orbit. It caused displacement of the entire orbit, outwards and downwards, with protrusion of the eyeball. The eye ultimately resumed its natural position, and the orbit also nearly returned into its normal place.

In one case in which, from the commencement, there had been mucous discharge from the enlarged sinus into the nose, as well as a fistulous opening in the skin, the latter closed spontaneously in about two years.

Portions of the wall of the expanded sinus may become absorbed; or a communication may be established between the right and left sinuses; or one or several fistulous openings leading into the orbit may exist.

The discharge of mucus through the incision or through a fistula in the skin may continue, or the incision may close, and the distension re-appear, and require re-opening, if the above treatment have not been adopted.

After the operation a deep cicatrix remains below the eyebrow, with light ptosis.

ACUTE INFLAMMATION WITHIN THE ORBIT.

Acute inflammation within the orbit often commences with more or less fever, and pain in the head. If it increases rapidly, it is accompanied by much swelling and redness of the eyelids and conjunctiva. The conjunctiva is œdematous (serous chemosis) if the inflammation is slight or deep-seated or circumscribed; it is infiltrated with more solid matter (fibrin, pus) if the inflammation is severe, e. g. if accompanied by suppuration of the eyeball. The swelling may be so great that the conjunctiva, protruding from the palpebral aperture, may become dry and covered with crusts; there is rarely much purulent discharge from its surface.

The eyeball in every inflammation within the orbit is displaced. Its movements are rendered painful and difficult, or are entirely prevented. A slight protrusion of the eye may appear considerable, from the great swelling of the lids. (See Ophthalmitis.)

At the commencement of the inflammation the cornea often appears

brilliant, the pupil contracted, the retinal veins large and tortuous, the retina œdematous, especially round the optic disc, which thus seems ill-defined, shading off into the adjoining fundus. The interior of the eye may however appear healthy; or morbid changes elsewhere may prevent us from obtaining a view of the retina, &c.

Vision may be slightly impaired or completely lost. The degree of impairment is frequently disproportionate to the visible intraocular changes. Flashes of light, fiery circles, &c., seen in the dark, are complained of in hyperæmia of the optic nerve.

The inflammation rarely remains confined to the tissues between the eyeball and the bony walls of the orbit.

The most frequent primary cause of this disease is some morbid change in the bony walls; but whether they are actually implicated cannot be decided, so long as no access to the seat of the inflammation, nor any opening for the escape of pus, exists. Inflammation if situated at the apex of the orbit is dangerous, and its course is very protracted, however circumscribed it may be.

If at the commencement the inflammatory action is not too severe, or if it is soon arrested, no abscess may follow. A secondary attack with protrusion may occur after the first has subsided. Patients may die from meningitis or phlebitis before an abscess has formed, or after perforation into the cranial cavity has taken place. This sometimes occurs suddenly after protracted suppuration, about the apex of the orbit. The more rapidly the inflammation increases the greater is the danger to the eye, as well as to the life of the patient.

An acute inflammation generally has passed its height in from ten to fourteen days, while the morbid changes which may have occurred in the eye, in the bones of the orbit, or in other structures, may continue for years.

The inflammation is rarely chronic unless it accompanies bone disease. Setting aside the changes in the functions and nutrition of the eye, we find that the inflammation either subsides gradually and disappears, or an abscess forms.

Besides the abscess following inflammation of the bones of the orbit (e. g. after injuries, fever, or erysipelas) we meet with rare instances of abscesses perforating the walls from without (e. g. abscesses in the frontal sinuses, or in the anterior lobe of the brain) and breaking through into the orbit. In cases of abscess in which death has occurred, a sero-purulent infiltration of the tissues of the orbit, with pus in the ophthalmic veins and the cavernous sinuses, has been found.

There may be very little swelling and redness of the parts round the eyeball previous to the appearance of pus. The abscess may perforate into cavities adjoining the orbit, or it may point beneath the conjunctiva

or somewhere on the surface of the lids, but rarely at more places than one.

An abscess behind the suspensory ligament of the lids generally perforates the conjunctiva; but the pus escapes through the skin of the lid when the abscess is formed in front of this ligament. After the escape of pus the eyeball often recedes, and the redness and swelling of the lids, conjunctiva, and tissue within the orbit disappear, if the cause of the abscess has been removed. In rare cases, though the lids and the eye return to their normal condition, an abundant discharge of pus continues for several months.

In a case of abscess within the cranium in which the patient recovered, portions of brain came away occasionally with the pus. Other cases in which the abscesses appeared simultaneously within the cranium and in the orbit, proved fatal. In a case of glanders purulent infiltration and sloughing of the tissue between the eyeball and the walls of the orbit occurred, together with one abscess in the choroid and another in the brain. The abscesses were surrounded by yellowish-grey and opaque infiltration.

When pus escapes from an opening leading into the orbit, or from an incision made in the course of treatment, a careful examination must be made for *diseased bone.* A probe may have to be introduced into the orbit at different times before rough or necrosed bone can be discovered.

Caries of the orbit is frequently superficial, but sometimes is seated as far back as the apex. Pain is, as a rule, felt when pressure is made on the bone near to diseased portions. If the latter be at or near the margin of the orbit, the diffused swelling of the bone and periosteum and the pain are generally well marked. The granulations round the opening from which discharge escapes appear flabby and bluish red, and the pus is dirty yellow, and frequently offensive as long as the morbid changes are progressing. The nature of the pus and of the granulations changes as the caries or other disease subsides; the granulations become less numerous, and of better colour; the pus becomes less abundant; and the sinuses and fistulous openings close. The openings may close before all the necrosed or carious portions are gone, in which case fresh attacks of inflammation will ensue. A patient has been attending at Guy's Hospital during the last seven years, on account of a minute fistulous opening situated near the outer canthus. Whenever this closes, protrusion of the eye and ophthalmia appear, and continue until, by pressure upon the temporal fossa, some pus is forced out through the opening. The portions of bone which from time to time come away are generally very small.

The bone during inflammation loses its hardness; its earthy salts become absorbed and the connective tissue predominates. Years may elapse before the disease comes to an end.

The cicatrices following loss of bone are deeper than those after any

other form of inflammation of the orbit; and according to their situation impair the functions of the neighbouring parts. If near the margin of the orbit they may, through contraction, cause ectropion, with or without destruction of the surrounding skin of the lids by inflammation.

The lachrymal gland may be destroyed.

Treatment.—In every case of inflammation of the orbit we adopt some general treatment, e. g. the anti-syphilitic treatment, if syphilis or the suspicion of syphilis exists; general antiphlogistic treatment (salines, bleeding from the arm, &c.), if injury is assigned as the cause.

If from the history of the case we infer the existence of a tumour, we treat according to the probable nature of the tumour. Cerebral disturbances and impairment or loss of vision are the chief complications to be avoided, whatever treatment we may adopt. Rest in bed must be enforced in all cases as long as the inflammation is acute.

We inform the patient of the danger to which the "sight" and the eyeball are exposed by the inflammation; and of the irreparable loss of "sight" which must ensue if signs of suppuration in the vitreous chamber are present.

A very protracted course must be expected if we find diseased bone.

The degree of intensity of the inflammation, the changes in its products, and their relation to the functions of the eyeball, indicate variations in the line of treatment. Some believe the change of inflammatory products into pus can be avoided by giving large doses of chlorate of potash; some recommend mercury as having the power of altering the character of the inflammation; others adhere to simple tonic treatment.

If we suspect the presence of pus, whether the inflammation be acute or chronic, an incision should be made. We thus avoid fistulous openings, and obtain better cicatrices. The incision should be made early, and without waiting until the pus "points." It must be made large, if, on introducing the finger, we find the periosteum pushed away from the bone by pus. If the pain is very severe, or the cornea in danger (its surface dull, misty), the protrusion being caused by changes outside the eyeball, a narrow long bistoury is thrust at once into the inflamed and swollen part between the wall of the orbit and the eyeball, where the latter is pushed furthest away from the former; or the bistoury may have to be passed in succession close along the upper and lower walls of the orbit if the eye is protruding straightforwards. A thorough acquaintance with the depth of the orbit and the direction of its walls, and with the course of the optic nerve, must guide us as to the depth to which the bistoury can safely be introduced, and the direction it should take. The bleeding relieves the patient, even if no pus escape. The incision is kept open by passing a probe into it daily, or by introducing some lint until the inflammation has somewhat subsided. After completing the incision, we should at once

ascertain whether there is any diseased bone, and what is its situation and extent, bearing in mind during the examination the thinness of the upper wall of the orbit, and the neighbourhood of the brain. The lids are kept closed by strapping, if the cornea is in danger.

Sometimes it becomes necessary to produce temporary adhesion of the margins of the eyelids in order to prevent ectropion, &c., arising from contraction of the tissue round fistulous openings.

If the inflammation of the skin and the pain are moderate, and the protrusion slight, we prescribe rest, frequent bathing with lint dipped in cold or iced water (as long as the sensation of cold is pleasant to the patient), and an appropriate general medical treatment, always trying the iodide of potassium with sarsaparilla. If no increase of heat is felt, we apply gentle pressure, by keeping pieces of lint, dipped in warm water, or in warm poppy-head lotion, tied over the closed eyelids; we also order the ungt. hydrarg. nitrat. mitius (a quantity the size of a pea) to be rubbed into the skin of the temple morning and night.

If the inflammation is severe, especially if the fever is great, and brain symptoms are present, frequent applications of lint dipped in iced water must be used, and changed as often as the lint becomes warm. In grown persons the effect of from six to ten leeches applied to the temple may be tried if no erysipelas exist.

If the tension of the eyeball is increased, or if hypopion from purulent infiltration of the cornea appears in the protruded eye, iridectomy or repeated tapping of the anterior chamber may be tried. Pus in the vitreous chamber, if there be much pain, must be let out by making an incision through the tunics of the eye, between the ocular insertions of the outer and inferior recti-muscles.

If after the incision has healed and the inflammation subsided the protrusion of the eye continues (e. g. from thickening of the soft parts of the orbit), a bandage causing slight pressure upon the closed eyelids must be worn for some time.

In protrusion from ophthalmitis, if there is much pain or prolonged sympathetic irritation of the fellow eye, excision of the eye is the shortest and safest treatment; frequent fomentations with warm water or warm poppy-head lotion will suffice in the absence of sympathy or pain. (See *Ophthalmitis*).

Necrosed bone generally comes away in small particles. It is extremely rare to find large pieces loose. Injections of warm water through the fistulous openings to facilitate the escape of the portions of dead bone, re-opening of fistulæ that may have healed if an attack of inflammation within the orbit with protrusion occurs after their closure, and appropriate general treatment, are the measures that can be recommended. Years may pass before such cases are well.

Syphilitic nodes if recent are tender to the touch; sometimes they are accompanied by much periostitis. They occur frequently along the margins of the orbit.

Periostitis accompanies most inflammations of the soft and bony parts of the orbit; its symptoms, if deep-seated, are those of inflammation of the soft parts within the orbit. It may assume an acute or a chronic character. It is readily recognized by the pain felt spontaneously, or when the inflamed portion is pressed upon. There is often also inflammation of the adjoining skin if the periostitis occurs along or near the margin of the orbit. It may lead to suppuration, and abscesses following it have been mistaken for cancer.

Periostitis complicating disease of the antrum and extending to the orbit. In the cases observed, paralysis of the third nerve, with chemosis and protrusion of the eyeball, preceded the loss of vision, which occurred rather suddenly, i. e. within a few hours from the commencement of the attack. No brain symptoms appeared. The periostitis probably caused rapid obstruction of the apertures leading into the orbit. Anæmia of the optic disc with good blood supply to the retina (showing the cause of Amaurosis to be situated behind the spot at which the vessels pass into the optic nerve) were the alterations observed with the Ophthalmoscope. From the permanent loss of vision and the subsequent atrophy of the optic disc, it may be inferred that the optic nerve-fibres were destroyed in their passage through the optic foramina.

The general treatment should be the same as is adopted in periostitis in other parts of the body. It must be carried on actively, on account of the dangers which threaten the eyeball and its appendages, as well as on account of the possible cerebral disturbances.

Inflammation of Tenon's Capsule.—This affection accompanies every acute ophthalmitis, and occasionally also occurs in cases in which a large portion of the sclerotic has been exposed during the operation for Strabismus. Slight impairment of the mobility of the somewhat protruded eyeball, and swelling and redness of the sub-conjunctival tissue and sclerotic, are observed. It resembles, if near the cornea, what is described as rheumatic ophthalmia.

Treatment.—Fomentations with lint dipped in warm water, or in warm poppy-head lotion, with appropriate constitutional remedies, constitute the treatment if the disease appears spontaneously.

If it occurs after an injury, the antiphlogistic regimen, ice, cold applications, &c., come into use.

INJURIES.

If we suspect the orbit to have been injured, we must bear in mind that inflammation of the bones, impairment of vision, and other morbid changes

caused by injury, may only become perceptible weeks or months after the accident has happened.

A foreign body may remain in the orbit for years before giving rise to disturbance. A cicatrix, e. g. in the upper lid, may guide us as to the spot at which it entered. If a recent wound exists, we should search at once for any foreign substance that may have passed into the orbit, and not wait for suppuration. We examine, if possible, the instrument with which the injury was inflicted, and inquire whether the patient suspects any portion to have remained in the wound. Throbbing in the orbit, displacement of the eyeball, pain round the orbit, indicate the probable presence of a foreign body. Otherwise, we treat as in cases of simple inflammation of the soft parts of the orbit.

A not unfrequent result of severe blows on the face is closure of the communication between the nasal cavities and the frontal sinuses, and the gradual enlargement of the latter. Concussion of the bones of the skull has in a few instances been followed by inflammatory changes, which have given rise to slight protrusion of the eyeball and to well-marked signs of aneurism within the orbit.

"Emphysema of the orbit," with protrusion of the eyeball from fractures of the inner wall of the orbit, readily subsides if slight continuous pressure is applied to the closed eyelids. Hæmorrhage beneath the conjunctiva or into the orbit has been observed after fractures of the upper wall of the orbit.

Amaurosis and Amblyopia have been known to result from injury to the supra-orbital nerve as well as from implication of this nerve in cicatrices, tumours, &c. Excision of a cicatrix, or of a portion of the nerve where implicated, has been followed by recovery in some, by improvement in other cases. With the Ophthalmoscope the optic disc has been found anæmic in some instances, and in others healthy in appearance together with the rest of the eye.

CHAPTER II.

THE EYELIDS.

ANATOMICAL AND GENERAL REMARKS.

The skin of the eyelids is thin and elastic, and the subcutaneous connective tissue loose and free from fat. The skin is freely moveable over the tarsal cartilages, and is thinnest where it becomes continuous with the conjunctiva. The loose and elastic tissue which connects it with the orbicularis muscle encloses hair-follicles, and numerous sudoriparous glands. These latter are small, and have tortuous ducts, each of which opens into the sheath of a hair near its root. The looseness of the subcutaneous tissue explains the ready accumulation of blood or serum beneath the skin, as, for example, after the application of leeches to the lids.

The Eyebrows (supercilia) are parallel with the upper margins of the orbits. They are very moveable downwards and inwards (e. g. when frowning), but hardly at all outwards and upwards. This peculiarity should be borne in mind when the surgeon is about to open an abscess or to remove a tumour, inasmuch as if the incision be carried along the eyebrow, the resulting cicatrix will be hidden.

The Eyelashes (cilia) project in two or three rows from the outer edge of the margin of each lid. They are further apart at their points of emergence from the lid than at their extremities. They vary in length, colour, and number. Those of the upper lid are thicker and larger. From one hundred to one hundred and fifty are in the upper, from fifty to eighty in the lower lid. They grow during a certain time. After having reached their full size, they become thinner again, and at last fall out, the follicles becoming atrophied.

An eyelash is supposed to have arrived at the term of its existence in about five months; after which time its place is occupied by a new one, Every hair follicle has numerous hair-bulbs, and the young hairs push

out the full-grown ones. Frequently a young lash may be seen projecting by the side of an old one; in which case the latter can readily be drawn out. After having nearly reached its full size, the lash grows very slowly. During the first month of its growth, it reaches a length of $\frac{1}{8}$ in., while, at the end of the fifth month, it has only increased to the length of somewhat less than $\frac{1}{2}$ inch altogether. The lashes of the lower lid grow less rapidly than those of the upper one. The hair-bulbs with their follicles are situated, some among, others beneath, the fibres of the orbicularis muscle; many are firmly adherent to the outer surface of the tarsus.

A horizontal incision through the lid about $\frac{1}{8}$ in. from its outer edge would pass through the largest number. Besides the proper eyelashes, there are numerous fine hairs projecting from the skin near them; these also have sebaceous glands.

The sebaceous glands of the lower lid are shorter than those of the upper ones; their ducts open into the sheath of the hair just before it reaches the edge of the eyelid. From two to five ($\frac{1}{76}$ of an inch in length, $\frac{1}{304}$ in. in breadth) go to each hair-follicle.

The cells in these glands resemble those of the sheaths of the eyelashes. They undergo a change into fat molecules.

The Meibomian Glands are readily brought into view when either of the lids is everted. They appear as yellowish, nearly parallel lines imbedded in the tarsus, shining through the conjunctiva, and passing towards the inner edge of the lid. About forty glands are in the upper, about thirty in the lower lid. Their ducts are straight. Their orifices open upon the rounded-off inner margin of the free border of the lid, previous to which two or three sometimes unite into one. On transverse section they are found to be surrounded by muscular fibres. In health, a greasy matter issues from the orifices. This consists chiefly of cells, the contents of which rapidly become changed into what resembles fat globules, which escape from the cells, and constitute "the secretion of the glands." This "secretion" spreads over the moving surfaces of the eyelids and eyeball, and mixes with the secretion of the conjunctiva. Mixed with air it gives rise to a white scum at the outer and inner canthi.

The Tarsus of each eyelid consists of dense fibrous tissue, with only a few cartilaginous cells. It is covered externally by the orbicularis muscle and the skin, and internally by the conjunctiva. It gives the eyelid firmness, and maintains the shape of the palpebral aperture. But for the tarsus, the levator palpebræ muscle would, when contracting, cause this aperture to become triangular; and it would appear round during the action of the orbicularis muscle. The convex or attached margin of the tarsus merges into a fibrous structure, termed the suspensory ligament of

the lid, which is inserted along the margin of the orbit. This is sufficiently strong to allow of the entire body being lifted from the ground by it. The tendon of the levator palpebræ muscle loses itself in it. Behind this fibrous structure we find the fat of the orbit.

The Muscles.—The levator palpebræ muscle raises the upper lid, the orbicularis muscle closes the lids. The latter is not a complete sphincter, but is interrupted ("inserted") at the inner palpebral ligament.

The different portions of the orbicularis do not contract simultaneously when closing the lids. The portion belonging to the lower lid is the stronger; it raises and slightly moves this lid inwards towards the inner canthus, even when the upper lid is fixed. The orbicularis muscle extends beyond the margin of the orbit where it is flat and thin. The portion which passes over and among the roots of the eyelashes is thicker than the remainder, and has been named the ciliary muscle (m. ciliaris). The relation of its fibres to the surrounding parts is not well understood. The functions of the glands, the direction and growth of the eyelashes, and the position of the margins of the lids, may be affected by morbid changes of the muscle.

The Nerves.—The seventh (facial) nerve supplies the orbicularis muscle; the third nerve, the levator palpebræ; and the fifth nerve furnishes the sensitive branches.

The Vessels.—The ophthalmic artery sends branches to the eyelids, the largest of which passes along the roots of the eyelashes, between the orbicularis muscle and the tarsus. The veins of the upper lid, like those of the eyeball, carry their blood into the opthalmic vein.

The outer and inner Canthi, i. e. the outer and inner angles of the palpebral aperture.—A fibrous structure passes from the temporal fascia at the outer angle, and from the periosteum of the frontal and maxillary bones at the inner angle of the orbit, over to the nearest portions of each tarsus. Before reaching the tarsi this structure splits into two portions, one of which goes to the upper, the other to the lower tarsus. The angle thus formed is termed the outer or the inner canthus, as the case may be; and the fibrous structure the outer or the inner palpebral ligament. Into the lower margin of the inner palpebral ligament numerous muscular fibres, coming from the outer anterior surface of the lachrymal sac, are inserted; it is likewise the point of insertion of some of the fibres of the orbicularis muscle, and by some it is described as the tendon of this muscle. It is readily made conspicuous by placing a finger on the skin near the outer canthus, and drawing the latter outwards, a

manipulation frequently resorted to during operations upon the lachrymal canaliculi.

The margin of the Eyelids.—We distinguish an outer edge of the margin (the one from which the eyelashes project) and an inner edge (which is rounded off, and rests against the eyeball) and a space between the two. The inner edges of the upper and lower lids do not touch each other when the lids are closed. This gives rise to a triangular space between the eyeball and the line along which the closed eyelids touch each other.

By momentary closure of the lids, i. e. by the act of winking, particles of dust, epithelium, &c., are wiped away from the surface of the cornea, and the secretions of the conjunctiva and lachrymal gland are spread over it, and the tears directed towards the lachrymal pasages. This act also exercises some influence upon the circulation of the blood in the choroid and retina. Eyes which become fatigued soon wink more frequently than others.

DEVELOPMENT.

About the sixth week of fœtal life we observe, as the first trace of the eyelids, two narrow folds of skin projecting from the face on either side of the nose. These gradually grow forwards and towards each other. About the end of the third month they have the shape of the eyelids, but they are open, and apparently too small to close completely over the eyeballs.

At the beginning of the fourth month the margins of the upper and lower lids touch each other, and become glued together, the palpebral aperture thus becoming temporarily closed. This closure persists during the fifth and sixth months. During this period some clear fluid becomes accumulated between the eyelids and the eyeball.

Neither eyelashes nor eyebrows are perceptible before the closure of the palpebral aperture. These, the meibomian glands and the tarsus, can be recognized about the end of the fourth month.

The hair-bulbs of the eyelashes appear a little sooner than the meibomian glands. The separation of the margins of the lids occurs first at the orifices of the meibomian glands, which temporarily give the free inner edges of the lids a somewhat serrated appearance.

CONGENITAL ANOMALIES.

Of the Eyebrows.—Anomalies as to quantity, colour, and position. Two eyebrows, one above the other (in which case repeated application of the tincture of iodine, and shaving off of one, has been found useful.)

Of the Eyelashes.—Trichiasis, and distichiasis, and differences in colour.

Of the Eyelids.—Absence of the eyelids, or congenital lagophthalmos; impaired growth preventing the complete closure of the lids. Coloboma of the upper and lower lids of one eye (with harelip) and a too narrow palpebral aperture (Symblepharon and Anchyloblepharon), or union of the margins of the upper and lower lids with each other. Complete or incomplete ptosis from paralysis or from anomalies in the size of the lids, or from defective development of the levator muscle. A third eyelid in the shape of a fold of skin advancing from behind the inner canthus over the eyeball. Pigment spots, nævi, fibrous tumours with or without hair and warts.

Epicanthus is another congenital anomaly consisting of a crescentic fold of skin which overlaps, more or less, the inner canthus of each palpebral aperture. Personal gratification may require its removal. This is done by pinching up and removing a vertical fold of skin from the bridge of the nose in a line with, and at an equal distance from, the inner canthi. The incision should be accurately united with sutures, and the epicanthus, if a sufficient quantity of skin has been removed, should have completely disappeared at the time of operation.

TUMOURS.

Cysts in the skin are often observed, especially in elderly people. They appear as little roundish watery-looking tumours, single or in groups, along the outer edge of the lid. Some may be as large as hempseeds.

The Milium is a small, yellowish-white, and opaque tumour (nodule) of the consistence of cartilage, projecting among the eyelashes from the margin of the tarsus. Several milia are generally present simultaneously. On minute examination we find that the milium consists of concentric layers of cells.

Treatment.—Cysts and milia have been successfully removed to improve the personal appearance, or on account of their irritating the cornea. So also have warts.

The Molluscum glandiforme, or albuminous tumour, is whiter than the milium. Its surface is shining, and slightly nodular. It projects from the skin, which is somewhat vascular if the molluscum is large. It may reach the size of a large pea. When squeezed milky fluid escapes through a small opening on the surface. It occurs frequently in children, accompanied by similar tumours in the skin of the lips, nose, &c., and is supposed to be caused by some animalcule having become lodged in a sebaceous follicle.

Treatment.—With a cataract knife the tumour is divided into lateral halves, and then nipped well with a pair of forceps, or better still between the thumb-nails. The halves of the whitish, nodular, solid substance are thus squeezed out. The empty bag of loose skin is left. The tumour "returns" if it has not been squeezed out thoroughly. All such tumours about the face or lids should be removed at one sitting.

The molluscum can always be removed in this manner; not so the milium.

The tarsal tumour (encysted tarsal tumour, cyst in the tarsus, chalazion). One or several such tumours may occur in the same eyelid. They are the result of morbid changes of the glands within the tarsus, and are often preceded by inflammation (Styes).

The tumour is usually situated near the inner surface of the tarsus. Sometimes it perforates the conjunctiva, and a few granulations surround the opening. When the tumour projects from the outer surface of the tarsus its position can be readily recognized by everting the eyelid. A darkish, grey-red spot covered with abnormally vascular conjunctiva indicates its situation.

Treatment.—Derangement of the functions of the eyelid, or of the cornea, or other reasons, may require the removal of the tumour by operation. If several tumours are present, all should be removed at the same time.

The patient, seated in a chair, rests his head against the chest of the operator, who stands behind. The hands and eyelids of the patient must be secured.

The tumour is removed through the conjunctiva. The eyelid is everted, and with a narrow, pointed knife an incision is made through the abnormally vascular conjunctiva, and the grey-red, thinned portion of the tarsus. The knife may have to pass through the entire thickness of the tarsus if the cyst is near the outer surface. The texture of the tarsus being very dense, some force has often to be used to carry the instrument through it into the tumour.

The incision, made parallel with the margin of the lid, should be equal in length to the greatest diameter of the tumour, as felt through the skin. A cross incision is sometimes necessary if the tumour is large. Generally some serum, pus, or grey gelatinous substance escapes at once. A small scoop is then carried along the surface of the tumour, with a view to separate the bulk of it from the surrounding tarsus. If this do not succeed, the scoop should be turned rapidly about to break away the gelatinous contents from the walls of the cavity. This must be continued until all seems to have escaped. Blood frequently fills the cavity, and the tumour often appears even larger than before the operation. If all the contents

have not been removed, we may at some future time be compelled to use the scoop a second or even a third time. This does not occur if the operation is performed thoroughly at first. Cold-water dressing is applied to the lids for a few days.

If after ten weeks the tumour or the hardness has not completely disappeared, a second operation may be required.

The sebaceous tumour.—This tumour is generally observed in children. It is congenital, and almost always situated beneath the skin, near the outer and upper margin of the orbit. It sometimes reaches the size of a small walnut, and if large, is in part adherent to the skin. The skin usually maintains its natural colour; sometimes it is vascular where the tumour is adherent; in rare cases, a small opening leads into the tumour, which, on pressure, gives vent to some sebaceous matter of an unpleasant smell. The matter is enclosed within a capsule of varying thickness, together with hairs of the shape and often of the colour of those of the eyebrows. These may be found attached to the sac, or curled up and mixed with the sebaceous matter.

Old tumours of this kind consist of yellow oily substance, enclosed in sacs of fibrous tissue which are often extremely thin.

The tumour is the less movable the more extensive its adhesion to the periosteum of the orbit.

Treatment.—The tumour, if thoroughly removed by operation, does not return. It rarely suffices to puncture it, and cauterize the interior. Chloroform should be administered, the operation being a tedious one, and accompanied with troublesome bleeding. Two assistants are required. The incision, if possible, should be made parallel with the margin of the orbit. It should always be sufficiently long to give easy access to the tumour. If the latter is large, a cross incision is required, or an elliptical one, if the skin is adherent to part of the tumour, so as to circumscribe the adhesion.

A pair of forceps to fix the tumour, and a cataract knife, or better, a strong, narrow-bladed, pointed pair of scissors, are used for the dissection. A good view of the tumour must be maintained by keeping open the large skin incision, and sponging away the blood. After having separated the adhesions of the tumour to the skin and other soft parts, we cut through its attachment to the periosteum, which may be broad, or have the form of a pedicle. The white sebaceous matter escapes if the tumour has been opened during the operation: this renders the complete removal difficult. Portions of the walls left behind should be touched with nitrate of silver.

Incisions through the suspensory ligament and removal of portions of

the fat of the orbit may readily be avoided by dissecting close to the walls of the tumour.

The wound being deep and lacerated some suppuration generally follows; lint, dipped into cold water, is applied as frequently as is pleasant to the patient. We may, to hasten union, insert one or two sutures near the corners of the incision. The wound heals in from two to three weeks; the cicatrix is scarcely perceptible, and no other disfigurement follows.

Nævus about the eyelids occurs frequently. One or several may be found in the same eyelid; or may extend from the eyelid into the orbit. The appearance and symptoms are similar to those elsewhere. If not operated upon, the nævus increases to a certain size, and then remains stationary, or becomes smaller.

Treatment.—Ligature, and injection of the tincture of perchloride of iron have been followed by sloughing of the eyelid. The safest and quickest method is to completely remove the nævus by operation, if its size and situation permit. The parts may be rendered insensible by the ether spray.

Another effectual method of treatment consists in the destruction of the nævus by means of the galvanic current.

Next to this can be recommended the insertion of stout silk threads, previously moistened with the tincture of perchloride of iron. Due regard must be paid to the portion of the eyelid we operate upon, in order to avoid disfigurement, displacement, &c.

Lupus has been observed in various stages in the eyelids, either extending from the face, or commencing in the lids (generally along their margins). By extension to the eye, or to the orbit, it has caused death in several instances.

It generally appears in young persons of otherwise good health; it spreads over large surfaces (different stages of the lupus being present simultaneously); it leaves peculiar star-shaped cicatrices; it is painless; and it is curable. In these respects it differs from epithelial cancer.

Syphilitic ulcers are, as a rule, primary, and commence with thickening along the margins of the lids.

Syphilitic infiltrations, from the slowness of their course, their hardness, and, if ulcerating from the dirty appearance of the ulcer, can hardly be mistaken for acne.

The local application of mercury is found of great use.

Cancer of the eyelids.—The medullary and melanotic forms are rarely primary. Nodules of both forms springing from the margins of the lids have been removed by excision.

Both forms frequently extend on to the lids from the eyeball or orbit.

Epithelial cancer appears under the form of small, roundish, hard nodules, or as so-called alveolar cancer.

The nodules situated in the skin of the lid, or over the lachrymal sac, at a later period become covered with yellow crusts, and overrun by enlarged veins. Beneath the crusts we find ulcerating surfaces with irregular outlines and everted margins, secreting but little pus, &c.

The alveolar cancer appears either as a defined tumour, or as an ill-defined infiltration. The latter form is less common; and occupies the skin, or commences beneath it, and is painful when touched. The dark red, nearly flat, surface of the cancerous infiltration after some weeks becomes ulcerated. Crusts appear with an offensive purulent discharge. The edges of the ulcer are swollen, roundish, and nodular.

Epithelial cancer has been mistaken for lupus. It may exist for years. In the alveolar form the neighbouring glands are much sooner affected. Cases have occurred in which the eyeball has been destroyed by numerous attacks of inflammation.

Treatment.—The cancer, if small, confined to the skin, and occurring in a strong patient, may be removed by operation. The loss of substance is covered by skin transplanted from healthy neighbouring parts.

The cancer re-appears more speedily if the operation be performed after the glands have become implicated.

The cancer may be also successfully treated by the application of a paste made of starch and chloride of zinc. The paste must be freshly made for each application.

The paste is spread over the surface and margins of the ulcer, and over a narrow strip of the adjoining healthy skin. The layer of paste should be sufficiently thick to hide these parts from view; and care should be taken not to touch the eyeball. The paste temporarily destroys the growth, and a cicatrix forms. The application is repeated whenever any part of the margin of the ulcer shows an inclination to extend itself, or when fresh nodes appear. The general health of the patient should be well supported.

Palpebral Ephidrosis is the term applied to an unusually large secretion of perspiration by the skin of the eyelids. In the cases observed it has been confined to the upper lids. On wiping away the confluent drops others soon appear. Slight ophthalmia and eczema are the consequences.

PHTHIRIASIS signifies the presence of crab-lice among the eyebrows and eyelashes.

The pear-shaped eggs of the crab-louse (Phthirius) are attached to the hair, close to the skin, by means of a transparent cement. A lid found at the broad end of the shell of the egg falls off on completion of the intra-oval life of the insect. The lice and their eggs, when present in large numbers, give rise to an appearance as if the eyelashes were covered with yellowish grey and brown crusts, as observed in Tinea. These crusts, on close inspection, present a marked beaded form, and when pressed between the nails burst suddenly.

Treatment.—The daily application of the Unguent. Hydrargyri Nitratis Mitius, or of a solution of the Hydrarg. Bichloridi (gr. i. ad aquæ ℥i.) by means of a camel's-hair brush, to the "crusts" on the eyebrows and eyelashes, suffices to destroy the lice within a few days.

PTOSIS.

Ptosis, or drooping of the upper eyelid, with inability of voluntarily raising it, may be caused by paralysis or paresis of the branch of the third nerve which supplies the levator palpebræ muscle before it reaches that muscle, or by alterations of nutrition of the muscle itself, or of the entire eyelid.

In the first case it is generally complicated with paralysis of the ciliary muscle, of the sphincter of the pupil, and of one or several of the recti muscles.

On raising the drooping lid we find divergent strabismus and the pupil somewhat enlarged and fixed. In complete ptosis, the upper lid hangs motionless, and the outer canthus appears lower than that of the fellow eye.

A slight impairment of the power of raising the upper lid is termed Paresis of the levator palpebræ muscle. The skin of the forehead in such cases is thrown into folds when an effort is made to raise the lid, while the skin of the lid hardly changes its appearance.

Treatment.—Ptosis may be the result—

1. Of severe or repeated inflammation, leading to hypertrophy and increase in weight of the upper lid.

2. Of protracted intolerance of light, with spasmodic closure of the eyelids producing hypertrophy of the orbicularis muscle, and thus destroying the antagonism between the orbicularis and the levator palpebræ muscle.

3. Of increase in weight of the lids in aged persons, from superabundance of skin, with weakness of the levator palpebræ muscle.

In all cases the action of the levator palpebræ muscle is often further impeded by narrowing of the palpebral aperture.

After all inflammation has ceased (1), and the intolerance of light has subsided (2), we can, by the removal of some skin, and orbicularis muscle, along the margin of the anterior surface of the tarsus, improve the condition of the patient, who, for personal reasons, or to improve the sight, may be desirous to undergo the operation.

To determine how much of the skin to remove, we pinch up a fold along and parallel with the margin of the lid, so as to raise that margin above the upper edge of the pupil while the eye is directed straight forwards. When the fold of skin is raised, the patient must be able to close the lids readily without effort. The fold is removed with scissors. Then, a strip of the orbicularis muscle, varying in width from one-fifth to one quarter of an inch, is dissected away from the tarsus, particular care being taken to remove the thick portion attached to the edge of the tarsus. One suture is applied midway between the outer and inner canthus, and is carried through the outer edge of the margin of the eyelid (tarsus) and through the nearest portion of skin. The wound heals within a few days. Cold-water dressing may be applied. The suture often comes away spontaneously.

Acute alterations of nutrition during œdema or inflammation of the eyelids, e.g. in the course of purulent ophthalmia, erysipelas, ophthalmitis, &c., cause the swollen and often immovable upper lid to overlap the lower one, the patient having but slight or no power of raising it. In such cases no treatment need be adopted so long as the cause (the purulent ophthalmia, &c.) has not subsided.

Ptosis from paralysis of the third nerve, the result of tumour, of syphilitic or rheumatic changes, or of abscesses in other parts, or occurring during congestion or hæmorrhage into the brain, as a rule, appears rapidly. The treatment must be directed against the morbid changes which may have caused the paralysis.

Some patients have derived benefit from raising the eyelid during the day by means of a metal suture, or strapping.

The operation of raising the lid by removal of some of its skin and muscular structure is not advisable.

An operation, the object of which is to raise the orbicularis muscle and tarsus beneath the skin of the eyelid, and thus to diminish the width of the drooping lid by a cicatrix formed between the displaced portions of the orbicularis muscle and tarsus and the skin, has in a few cases proved successful. An incision is first made parallel with, and about an eighth of an inch from the outer edge of the margin of the eyelid through the skin down upon the orbicularis muscle. The skin is then dissected away from the orbicularis to the extent of the tarsus, and a little beyond its upper margin. A loop of silk is next passed round some of the bundles of the orbicularis muscle, near the margin of the eyelid at an equal distance

from the outer and inner canthus. The silk is carried upwards beneath the skin and out at the eyebrow and fixed there. One or two more silk threads may be inserted in the same way along the margin of the lid. The effect is to raise the tarsus and orbicularis muscle behind the skin, which is thrown into folds and overlaps the margin of the lid.

Cold-water dressing is applied frequently, and the patient should be kept in bed for about a week. The swelling, &c., of the lid has been considerable in several cases. The silk threads are removed about the eighth day, by which time the displaced muscle and tarsus are supposed to have become adherent to the skin.

PARALYSIS OF THE ORBICULARIS MUSCLE (SEVENTH NERVE).

The paralysed eyelids are wide open and cannot be closed at will; and the margin of the lower lid sinks away from the eyeball.

A thorough voluntary relaxation of the levator palpebræ muscle, however, nearly suffices to "close" the upper lid. The lid remains immovable if the levator is likewise paralysed.

In rare cases, though the power of moving the lids voluntarily may be lost, reflex movements (during sneezing, exposure of the eye to strong light, &c.) may still occur. The continued exposure of the eyeball gives rise to epiphora, irritation, inflammation of the cornea, &c.

PARESIS OF THE ORBICULARIS MUSCLE.

The more prominent symptom of Paresis is epiphora, accompanying inability to close the lids forcibly, or to throw the skin of the lids into folds.

The causes of paresis and paralysis are—intercranial changes (e. g. congestion of the brain, apoplexy, &c.), which generally affect both orbicularis muscles; morbid changes of the structure of the orbicularis muscle itself, or of the parotid, or of the seventh (facial) nerve. The paralysis may be confined to those branches of the nerve which go to the orbicularis muscle.

The treatment belongs essentially to the domains of general medicine and surgery.

The irritation caused by the epiphora, and by exposure of the eyeball to the air, &c., is best overcome by keeping the eyelids continually closed.

NEURALGIA.

Neuralgia in the frontal branches of the fifth nerve ("pain over the eyebrows," "in the forehead") appears in rare cases independently of the eye. In such cases, especially if periodical, three to five grain doses

of quinine will be found of use. Still better are subcutaneous injections of a solution of the acetate of morphia.

Similar injections beneath the skin of the temple are of temporary use also in those forms of inflammation of the eye which are accompanied by severe pain. The effect is produced in a quarter or half a minute after injection. A quantity, of from $\frac{1}{10}$ to $\frac{1}{2}$ of a grain, generally $\frac{1}{5}$ or $\frac{1}{6}$ of a grain, of the acetate of morphia in solution is injected at one time.

In irritable people even small doses cause sickness or vomiting, with shortness and quickness of breath.

We should not neglect, in cases of neuralgia, to examine the refraction of the eye, particularly if pain is felt during reading. Properly selected spectacles have often removed long-continued neuralgia.

SPASM OF THE MUSCLES OF THE EYELIDS.

SPASMODIC CONTRACTION OF THE LEVATOR PALPEBRÆ MUSCLE.

This form of spasm occurs very rarely. The eyelids during the spasm are wide open. The upper lid resists attempts to close it with the finger. This affection has been observed during morbid changes of the urinary organs and after injuries.

SPASM OF THE ORBICULARIS MUSCLE (BLEPHAROSPASMUS). SPASMODIC CLOSURE OF THE EYELIDS.

Blepharospasm is frequently observed. Morbid changes in the seventh (facial) nerve, or cerebral changes may give rise to it. Sometimes it appears combined with neurosis of the facial nerve, and spasm of the ciliary muscle. Most frequently it is the result of morbid changes of the surface of the cornea acting upon the sensitive nerves (first division of the fifth), and of these in their turn re-acting upon the seventh.

The spasm may continue after the primary cause (irritation of the fifth nerve) has subsided; or it may have given rise to Entropion, which in itself keeps up the irritable condition of the cornea and the spasm.

Treatment.—The spasmodic closure of the red, swollen, and tense lids occasionally occurring in the course of purulent ophthalmia, subsides on the cessation of the ophthalmia, unless kept up by morbid changes in the cornea.

The spasm when accompanying inflammation of the tunics of the eye (especially syphilitic and pustular corneitis, ulcers, abscesses, and abrasion of the cornea), sometimes continues after all inflammatory changes have passed, and is attributed to undue irritability of the orbicularis muscle itself.

The spasm readily subsides after the insertion of a seton into the skin

of the corresponding temple; or after division of the supra-orbital nerve, by which means the muscle is rendered temporarily insensible.

The forms of spasm, in which the eye appears otherwise healthy, are often accompanied by Neuralgia. In such cases, spasmodic contraction (e. g. of the face) may lead to spasm of the orbicularis, and *vice versâ*, spasm commencing in the orbicularis may spread to other muscles. In one case epileptic fits were finally induced, which ceased after division of the supra-orbital nerve.

In such cases we must ascertain whether the spasm is arrested by digital pressure upon the sensitive or upon the motor nerves of the orbicularis, or upon both kinds of nerves or upon their branches.

The nerves which deserve our special attention are the supra-orbital, the infra-orbital, the subcutaneous malæ, the lower maxillary, and the auriculo-temporal.

Sometimes we find diseased bone or periostitis to be the cause, and by medical treatment succeed in removing the spasm. Generally, however, we are compelled "to perform Neurotomy," i. e. to divide the nerve-branches, and the arteries next to them, which, when pressed upon, cause the spasm to cease.

For these operations chloroform should be given. The instrument for dividing the nerve and artery is thrust through the soft parts down to the periosteum, close to the spot where we propose dividing the nerve. It is then carried along the periosteum, to and a little beyond the nerve, and the latter, together with the artery and periosteum, are cut through. Pressure, by means of a pad of lint, is applied to arrest hæmorrhage.

Hyperæsthesia of the retina occasionally gives rise to spasm, or to frequent winking. The hyperæsthesia may be accompanied by an unusual sensibility of the cornea and conjunctiva.

Attention must be paid in these cases to the tension and refraction of the eye (anomalies of which are a common cause of hyperæsthesia).

Trembling or spontaneous twitching ("the live-blood"), especially of the lower lid, which may increase to spasmodic closure of the lids, is observed in many hypermetropic persons. It is probably a symptom of undue contraction of the ciliary muscle. It often ceases after the instillation of atropia, or after treatment of the hypermetropia.

A blister in front of the ear (over the seventh nerve), or the endermic application of atropia (gradually increased from $\frac{1}{12}$ to $\frac{1}{4}$ of a grain of atropia) has also been found of use.

The spasmodically-closed lids exercise continued pressure upon the eye-balls, and may thus cause protracted impairment of sight. This complication or changes in the cornea may require the speedy removal of the spasm by division of the supra-orbital nerve.

For the treatment of Entropion, with spasm of the orbicularis muscle, see Entropion.

INFLAMMATION OF THE EYELID.

The term *Anchylops* is applied by some to circumscribed inflammation about the eyelid at the inner canthus; and the term *Ægilops* to perforation of an abscess at the inner canthus. Inflammation of one or several of the glands of the eyelashes is described under *Acne Ciliaris;* inflammation of the bulbs and follicles of the eyelashes under *Tinea,* and acute inflammation of the meibomian glands under *Stye.*

The causes of inflammation commencing in the eyelids, are injuries (burns, blows, stings from insects, &c.), severe illness (Scarlatina, Measles, Pyæmia, &c.). More frequently, however, the inflammation follows or accompanies severe inflammation of adjoining parts, as purulent ophthalmia, ophthalmitis, erysipelas, inflammation of the glands adjoining the eyelids, &c.

The swelling of the "inflamed" lid or lids is generally considerable, and often prevents their being opened. It is caused by the rapid increase of nuclei and cells of the various structures of the lid, and by these structures becoming infiltrated with serum and blood.

No case is recorded in which abscess has followed inflammation accompanying purulent ophthalmia or ophthalmitis. Abscess "by metastasis" often forms if the inflammation appears after severe illness. The skin becomes tense and painful to the touch until pus has escaped.

The pus occasionally perforates the conjunctiva, or it undermines the skin and escapes through several openings. Abscess occurs more frequently about the eyebrows, the upper lid, and near the inner canthus. In the latter place it may be mistaken for abscess of the lachrymal sac.

The inflammation generally passes off without permanently disturbing the appearance and functions of the lid. If occurring repeatedly in the same lid it gives rise to hypertrophy.

Disturbances of the functions of the lachrymal passages, cicatrices irritating the cornea or disfiguring the lid, Ectropion, Entropion, or Symblepharon, may follow the inflammation. Sloughing of part or of the whole of one or both of the eyelids has been observed in inflammation following Erysipelas, and after severe illness.

Treatment.—At the commencement of the inflammation when caused by injury, we order the frequent application of pieces of lint dipped into cold or iced water to be continued as long as the sensation of cold is pleasant. Applications of lint dipped into cold water should be tried also in inflammation from other causes, but must be discontinued if the cold is unpleasant, and a simple poultice during sleep, and the frequent use of lint dipped into warm water or into warm Lotio Papaveris may be substituted.

If an abscess is found, an incision is made at once parallel with the margin of the inflamed lid, and sufficiently large to allow of free escape of pus. Sometimes a small spontaneous opening has to be enlarged, or several openings have to be united into one, or a counter opening may have to be made into the skin after spontaneous perforation of the abscess through the conjunctiva.

The lids after the pus has escaped are kept closed by the application of lint dipped into warm water, and by a bandage which should exercise gentle pressure. The lint has to be changed frequently. Bathing the eyelids with Lotio Aluminis for five minutes several times during the day will be found of use if there is purulent or mucous discharge from the conjunctiva.

The state of the eyeball may require examination; in which case the swelling sometimes necessitates the use of the wire speculum. This operation is painful, and requires the administration of chloroform.

In inflammation of the eyelids as a complication of changes of the eyeball, we must inform the patient, or parents, of the danger which threatens "the sight;" otherwise the loss of sight might be attributed to our treatment.

A small abscess occasionally occurs in the follicles near the inner edge of the margin of the eyelid. A vascular, somewhat swollen patch close to the inner edge of the tarsus beneath the conjunctiva, with a yellow spot in its centre, indicates the position of the abscess. If it touches the cornea it gives rise to disturbances of vision, and may require puncturing.

Care must be taken to adapt the general medical treatment to the cause of the inflammation. For the treatment of inflammation accompanying morbid changes of the glandular structures of the eyelids, see Acne, Tinea, Stye.

Anomalies in the position of the lids, and in the function of the lachrymal apparatus following inflammation, are more successfully treated if the inflammation is first allowed to pass off completely, unless it be kept up secondarily by these changes themselves.

THE STYE (Hordeolum).

The Stye is a small, red, roundish, smooth, hard, and elastic swelling situated "in the eyelid," with the skin movable over it, and with the swollen red margin of the lid rounded off if the stye is near it. It is caused by morbid changes of one or several of the Meibomian glands, accompanied by more or less acute inflammation. On everting the eyelid, a greyish or yellowish ill-defined spot, surrounded by vascular, and sometimes granular, or swollen conjunctiva, may be seen. This indicates the portion of the stye which lies nearest the conjunctiva. Small styes may escape notice. Several may appear simultaneously. They are the more

conspicuous the more the skin and tarsus are implicated in the inflammation. The swelling of the lid or lids may be so considerable as to prevent their being opened.

The lid, at the commencement, "itches," or feels "stiff;" it then becomes painful. Some patients at first complain of headache, and feverishness. In a few days the matter points; at last some pus escapes, generally near the margin of the lid through the conjunctiva, or through the skin, together with a peculiar greyish gelatinous-looking substance, consisting of ill-developed connective tissue. In rare instances the pus escapes into one of the lachrymal canaliculi. The lid, after this, either soon resumes its natural appearance, or "a granulation," or some grey and opaque substance, may be seen for a considerable time projecting from the opening of the perforation, especially if situated in the conjunctiva. In some cases no perforation is observed. In others the stye, sometimes without preceding acute inflammation, or after escape of pus, takes on a chronic course and appears as a little hard tumour in the substance of the tarsus. It is then termed a chalazion.

In chalazion we generally find ill-developed connective tissue, mixed with a fatty or chalky-looking substance. If the chalazion, however, is old, a brownish turbid, or a clear oily fluid is found. The skin and conjunctiva over it are unduly vascular.

Styes occur in persons of delicate health, and in those troubled with acne; and sometimes after or during the different forms of purulent ophthalmia. They frequently re-appear periodically in the same eyelid during several years.

Treatment.—At the outset of the acute inflammation we order the lid to be washed frequently during the day with Lotio Papaveris mixed with hot water in equal proportions, and a hot linseed-meal poultice to be applied over the closed eyelids during sleep.

A small incision parallel with the margin of the eyelid through the part where the pus points hastens the course, and relieves the patient sooner, but it need not be insisted upon if an operation should be objected to. Appropriate general medical treatment and bathing the inflamed lid with Lotio Papaveris, suffice after the escape of pus. All redness and swelling should have disappeared in from two to four weeks after the commencement unless a chalazion follows, which for its removal requires an operation.

ACNE CILIARIS.

Acne ciliaris signifies inflammation of one or several of the glands of the eyelashes. The gland or glands become expanded, their secretion is morbidly altered, the nutrition is disturbed, and the surrounding tissue becomes inflamed. This affection varies in degree, and occurs more fre-

quently in the upper than in the lower lid, probably on account of the glands being larger and more numerous in the former than in the latter.

Externally, if the inflammation is severe, we find the entire lid red and œdematous, and the skin over the swelling tense and painful. If the inflammation becomes developed rapidly, suppuration of the contents of the gland may follow, with perforation of the skin at or near the edge of the lid. The patient may be feverish at the commencement of the inflammation.

If the inflammation is slight, we find a circumscribed roundish, defined red swelling at or near the outer edge of the lid, with a few dry, yellow, and opaque crusts adhering to it and to the eyelashes. The margins of the lids sometimes undergo changes similar to those observed after tinea.

Acne, though observed at any age, and usually in the spring of the year, appears most frequently about puberty, and in persons who have acne nodes in other parts. The course is generally chronic in consequence of the glands becoming affected in succession.

Treatment.—A small vertical incision is made into the inflamed skin if the pain is great to let out blood or pus. A linseed-meal poultice is placed upon the closed lids during sleep, until all redness has disappeared. In other respects we adopt the local treatment of tinea.

Pustular ophthalmia and corneitis, which often exist simultaneously with acne, require separate treatment. We also adopt the general medical treatment which is usual for the removal of acne in the skin.

TINEA.

(*Tinea ciliaris ; Blepharitis ciliaris, or marginalis ; Tinea palpebralis ; Follicular Blepharitis ; Psorophthalmia.*)

Patients suffering from tinea generally present themselves with yellow, dry, and opaque crusts adhering to the eyelashes. Parts or the whole of one or both eyelids also are slightly red and swollen along the margin.

The crusts consist chiefly of dried pus. We find, after their removal, the surface of the margin of the lid raw or fissured, easily bleeding, and scattered over with small ulcerations (the result of pustules). The entire margin may be thus changed into an ulcerating surface. Its inner edge sometimes appears uneven, from granulations springing up during the course of the tinea. Considerable swelling of the lid, with pain and intolerance of light, may occur in the commencement of the inflammation, especially if complicated with pustular, catarrhal, or granular ophthalmia, as is often the case.

The course of the disease is chronic, and may be protracted through life. It frequently recurs at certain periods of the year, e. g. every spring.

When the disease is at an end the crusts fall off, and the corre-

sponding margin of the lid appears thickened (so-called Tylosis, or Pachyblepharosis).

The tissue surrounding the roots of the hair-follicles becomes hypertrophied, and the nutrition of the eyelashes impaired, unless tinea is properly treated.

The margins of the lids appear rounded off, and the skin and conjunctiva in extreme cases are blended into one smooth, red, shining cicatrix, without eyelashes or meibomian gland orifices. A few badly nourished pale eyelashes may be seen, which, by thickening of the margin of the lid, or by cicatrices following the ulcerations, are displaced, inverted, &c. The conjunctiva is more or less everted. Ectropion through destruction of skin and contraction of cicatrices may follow.

This extreme stage of tinea is termed *Lippitudo.* Displacement or closure of the lachrymal puncta and canaliculi, with epiphora, continuous winking, and irritability of the eye, are frequent sequelæ.

Among *constitutional causes* must be mentioned variola, measles, scarlatina, and especially syphilis; among *local causes* the different forms of purulent ophthalmia.

Tinea occurs most frequently in children and in young persons.

Treatment.—An anti-syphilitic or a tonic treatment is adopted according to the general aspect of the patient. Much benefit is derived from the "Liquor Fowleri," especially if the upper lip and alæ nasi are swollen at the same time. To adults we give gutt. x. of the Liquor with Mist. Ferri Co. to be taken twice daily. For a child six weeks old, we order Vini. Ferri ℥ iii. Liquor Fowleri gutt. iii.; one teaspoonful to be taken twice daily.

Exercise in the open air, and general cleanliness must be enforced.

Locally we have to prevent the accumulation of crusts. These are most easily removed by patiently touching them with a sponge dipped in warm water, or better still by using the eye-douche with warm water, until they are softened, and can be wiped off. The inflamed margin of the lid is then dried, and the places from which the crusts have been removed are painted over with a camel's-hair brush dipped in Lotio Plumbi Acetatis. This is repeated three times daily. At bed-time, after using the lotion, some Unguentum Hydrargyri Nitratis Mitius, made with glycerine, is applied with the camel's-hair brush, or with the finger, along the inflamed margin of the lid.

If after the removal of the crusts we find many ulcerations or fissures, we either make punctures into the skin, along the edge of the lid, so as to abstract some blood, or touch the ulcerations with the solid nitrate of silver, or apply a solution of the latter (half a drachm of nitrate of silver to one ounce of distilled water) with a camel's-hair brush. This application has to be repeated every second day as long as crusts are found. Some re-

commend Calomel powder to be sprinkled upon the skin along the edge of the lid instead of applying mercurial ointment.

If Tinea have existed for a long time, or the margin of the lid have become much thickened, lint, steeped in a strong solution of nitrate of silver (℥ i. ad aquæ ʒ i.) has been recommended to be tied over the closed lids. The lint should be changed twice daily.

In Lippitudo we slit open the displaced tear-puncta and canaliculi, if epiphora exists. The patients, as a rule, are very nervous, and render this little, but essential operation somewhat difficult.

DISTICHIASIS.

Distichiasis signifies a faulty direction of one, or of several, or of an entire row of the follicles of the eyelashes, causing the latter to become turned towards the eyeball, while the position of the margin of the eyelid is not disturbed. The eyelashes may appear healthy. Frequently they are thin, pale, and curly.

TRICHIASIS.

Trichiasis indicates a faulty direction of the healthy, or crippled eyelashes from abnormal position (inversion) of part, or of the entire margin of the eyelid. The turned-in eyelashes, especially if the cornea is touched, cause intolerance of light, spasmodic closure of the lids, "watering," and "redness."

Corneitis, ulcers of the cornea, and even shrinking of the eyeball, with loss of sight, have been observed to follow in neglected cases. Little irritation is complained of, if the cornea, or cicatrices occupying its place, have lost their sensibility.

Distichiasis may occur as a congenital anomaly of the position of the hair-follicles, or may follow inflammatory changes of the same.

Trichiasis frequently accompanies the later stages of neglected granular ophthalmia, the shrinking conjunctiva and tarsus producing entropion. A common cause is "inflammation" of the glands and hair-follicles of the lid causing cicatrices with distortion of the margin.

Treatment.—If few eyelashes are displaced, they should be drawn out gently with the cilia forceps (without breaking them off). Frequent repetitions of this may produce atrophy of the hair-papillæ. Some recommend the removal of the hair-papillæ by operation.

The growth of fresh eyelashes may be prevented for months, by applying some Sulph-hydrate of Calcium to that portion of the margin of the eyelid which surrounds the orifices of the eyelashes. The Calcium, after five minutes, is washed away with a sponge. During the application a spatula is placed between the lid and the eyeball to protect the latter.

The papillæ of the eyelashes may be destroyed with pure Liquor Potassæ. To do this a needle, moistened with the Liquor, is thrust along the eyelashes in the direction of, and a little beyond, the papillæ. Slight inflammation follows. The eyelashes after a few days are drawn out with the forceps.

If a bunch of eyelashes is "turned in," a V-shaped piece of skin and muscle enclosing the eyelashes and their papillæ may be removed, care being taken to excise some of the normally-directed eyelashes on either side of the bunch, and to unite the wound, so that the subsequent cicatrix may not cause inversion of others.

If the turned-in eyelashes are scattered over the entire margin of the lid, and if for this, or other reasons, we determine upon their entire removal, we must take great care to spare the margin of the tarsus so as to preserve its width as much as possible. The inner edge of the tarsus must be kept intact, otherwise obliteration and atrophy of the meibomian glands, or thickening and distortion of the tarsus, with accumulation of the secretion of these glands, or eversion of the conjunctiva with irritating cicatrices, or epiphora (if the lower lid has been operated upon), may follow.

The operation.—In this and other operations on the eyelids, a compressorium forceps is applied, in order to avoid troublesome bleeding. The forceps should not be tightened more than will suffice to stop bleeding, otherwise much inflammation, or even sloughing of the lid, may follow. The forceps being applied, we first with a cataract-knife split the margin of the lid so as to separate the skin, orbicularis muscle, and eyelashes (their hair-follicles included), from the tarsus. We take care not to wound the lachrymal canaliculi, nor to leave behind eyelashes or their roots. The latter appear as little black dots on the surface of the tarsus. The incision is carried to about a quarter of an inch from the margin of the lid. A second incision, a quarter of an inch from the margin of the lid, and parallel with it, is then carried through the skin, &c., down upon the tarsus. The parts including the hair-bulbs and eyelashes are removed. No suture need be applied.

The bleeding is arrested by means of wet lint tied over the closed lids. The lint should be changed whenever it becomes dry. The patient may go about his usual occupation. The wound generally heals in the course of two or three days.

Eyelashes that may have been left behind, if irritating the eye, must be extracted with the forceps.

ENTROPION.

(*Inversion or turning in of the eyelid towards the eyeball.*)

Entropion is generally observed in the lower eyelid. It sometimes becomes apparent only after the lids have been forcibly closed.

In aged persons both the lower lids are not unfrequently found turned in to such an extent that the palpebral margin in each eye lies within the fornix of the conjunctiva, causing little or no irritation.

In slight degrees of Entropion, the margin of the lid is but little inverted, and the eyelashes touch the cornea only when the eyeball is turned downwards. In such cases, if allowed to continue for a long time, permanent changes in the size and shape of the tarsus occur. The eyelashes, or the free and often uneven margin of the lid, if touching the eyeball, especially the cornea, for a considerable time, cause watering and eczema of the inverted lid, chronic ophthalmia, ulceration of the cornea, &c. Perforation of the cornea, escape of vitreous, and shrinking of the eyeball, have occurred in consequence of neglecting Entropion.

The most frequent causes are:—(1.) Changes of shape, size, and consistence of the tarsus through cicatrices. (2.) Protracted tinea, with trichiasis, inducing spasmodic closure of the eyelids, and, finally, distortion of the tarsus. (3.) Prolonged granular ophthalmia, causing softening, enlargement, and subsequent shrinking and distortion of the tarsus, with cicatrices in the conjunctiva and Blepharophymosis. (4.) The action of the orbicularis muscle alone. Entropion may occur from this cause if there be want of tension of the attachments of the tarsus, or from flaccidity of the tarsus itself, or want of support of the lids through loss of the eyeball. In children especially we observe Entropion from spasm of the orbicularis during ophthalmia, corneitis, &c.

Treatment.—In Entropion with distortion or thickening of the tarsus, it is necessary to remove a wedge-shaped piece of the tarsus. If Blepharophymosis exists, as is frequently the case, this must also be treated. See Blepharophymosis.

In Entropion following removal or shrinking of the eyeball, if no artificial eye can be worn, we close the palpebral aperture by operation.

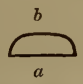
In Entropion of the lower lid, with loose skin, as often observed in aged persons, if an operation be objected to, the application of collodion, or of strips of sticking-plaister, to the skin of the lid may suffice to keep it in its natural position.

The operation should, however, be recommended as the most speedy means of cure.

Entropion, with inflammation, enlargement, and relaxation of the lids, occurring during ophthalmia in children, generally subsides spontaneously if the ophthalmia be treated properly, i. e. by the insertion of a seton into the temple when there is corneitis, together with the use of Lotio Aluminis if there be also purulent discharge.

Some patients avoid the troublesome diplopia by closing the lids of the affected eye, using only the normal eye.

Entropion, in consequence of thickening, distortion, cicatrices, &c., of the tarsus (e.g. after granular ophthalmia), or Entropion of circumscribed portions of the thickened eyelid, *is treated by removal of a wedge-shaped portion of the tarsus.* The tarsus, thickened near its margin, often presents, on everting the lid, a cicatrix or indentation which corresponds to the thickened portion. The object of the operation is the removal of this thickened portion, or of part of it, including, if possible, the cicatrix in the conjunctiva.

The operation is more difficult if performed without a compressorium forceps. If no compressorium forceps should be at hand, a spatula is placed between the lid and the eyeball to support the former and protect the latter. If we employ the forceps, the solid blade is pushed between the lid and the eyeball, while the other blade is placed upon the skin. By tightening the screw the lid is compressed, and troublesome bleeding prevented. Screwing too tightly has been followed by severe inflammation. With a sharp cataract knife an incision is then carried through the entire thickness of the lid down to the conjunctiva, parallel with, and about a sixth of an inch from, the outer edge of the margin of the lid (or along the portion of the base of the most thickened part of the tarsus which lies nearest this edge). The incision should extend along the entire portion of the margin of the lid, the position of which we wish to correct. It is of little consequence if the conjunctiva be cut through. A similar incision to meet the ends of the first one is next carried along the base of the thickened part of the tarsus which lies furthest from the margin of the lid. The surface of the piece of tarsus thus circumscribed by the two incisions has somewhat this 

shape. The straight line (*a*) represents the first, the curved line (*b*) the second incision ; the surface between these corresponds to the piece of tarsus we have to remove. This piece should be wedge-shaped. Incision (*b*) must be therefore carried slantingly through the tarsus so as to meet incision (*a*) at the surface of the tarsus nearest the eye. The wedge-shaped portion is then removed. The skin, muscle, &c., covering the surface of the tarsus, if we do not wish to remove them, are dissected back after the first incision has been made.

The edges of the wound are united by one or two sutures; after which the margins of the lid should appear slightly everted. Water-dressing is applied, and the lids are kept closed for a few days. The wound in the tarsus unites rapidly.

The kind of Entropion treated thus is generally complicated with Blepharophymosis, which should be remedied if the position of the lid is not completely corrected by the above operation.

Entropion, if the tarsus is not thickened or distorted by cicatrices, can

be remedied *by establishing one or several cicatrices in the integuments of the inverted lid.*

As close as possible to the outer edge of the margin of the inverted lid, a needle armed with strong waxed thread is thrust through the skin and other soft parts. It is carried along the outer surface of the tarsus, and brought out again about $\frac{1}{3}$ in. from the point where it entered. The distance of these two points from each other, and with it the quantity of skin, muscle, &c., enclosed by the thread must be regulated by the degree of the Entropion. By pinching up a fold of skin parallel to the margin of the lid previously to inserting the needle, we can in a measure ascertain how much of the skin, &c., need be enclosed. The thread is tied firmly so as to strangulate the skin, muscle, &c., and is left to come away by suppuration. This requires from six to ten days. The linear cicatrix which remains is expected to keep the lid in proper position. Several of these cicatrices may be required if the Entropion be considerable. The threads have to be removed if erysipelas appears.

Entropion treated by removal of a fold of skin, &c.—The relaxed skin of the inverted lid is seized close to the margin by the finger or forceps, and raised into a horizontal fold, so that the inner edge of the margin of the lid is slightly drawn away from the eyeball. If sufficient skin has been pinched up the patient when forcibly closing the lids will not be able to produce Entropion. The fold of skin is then removed by scissors. A narrow strip of the entire thickness of the exposed portion of the orbicularis muscle, about $\frac{1}{5}$ in. wide, is likewise taken away close to the margin of the lid.

Two or three sutures are applied to convert the wound-surface into a linear incision. Immediately after the operation the margin of the lid should be very slightly everted. Water dressing is applied for a few days.

Entropion of the lower eyelid, at or near the outer canthus, caused by enlargement and flaccidity of the eyelid, is removed by displacing the margin of the lid so as to render it less flaccid.

An incision about $\frac{1}{3}$ in. long, and commencing at the outer canthus, is made through the skin and other soft parts horizontally outwards down to the external palpebral ligament and adjoining periosteum. Two other incisions, likewise extending to the periosteum, the one from the beginning, the other from the end of the horizontal incision, are carried downwards, and made to meet at an angle, on a level with the lowest point of the lower margin of the orbit.

The soft parts enclosed by these incisions are dissected away, and the margins of the two downward incisions are united by sutures. The operation should have the effect of stretching the margin of the lower lid over the eyeball, and keeping it in proper position.

ECTROPION.

(EVERSION OR TURNING OUT OF THE EYELID.)

Ectropion varies in degree from slight sinking away of the inner edge of the lid from the eyeball to complete eversion of the entire lid, and of the adjoining fornix of the conjunctiva.

The conjunctiva, exposed to the air, &c., appears unduly vascular in recent cases. It gradually becomes hypertrophied and granular. Accumulation of tears in the sulcus between the lid and the eyeball, and epiphora, are frequent complications.

The cornea, if continually exposed, becomes vascular. Opacities, infiltration, and ulcers, &c., appear. This occurs sooner in old and weak patients.

Ectropion of the swollen eyelids is observed during purulent and other forms of ophthalmia, especially in children. Its occurrence is favoured by the spasmodic action of the orbicularis muscle, or by attempts to inspect the cornea.

Causes.—Cicatrices from injuries, burns, ulcers, &c., in or near the lids. Shortening, or destruction of the skin, or of the skin and suspensory ligament of the eyelids, or of the tarsus.

Atrophy of the orbicularis muscle from undue extension caused by protrusion of the eyeball or by inflammation of the eyelids. Paresis or paralysis of the orbicularis muscle, as frequently seen in old persons.

Acute inflammation of the conjunctiva, with much chemosis, especially if the tarsus has become softened. Long continued overflow of tears and mucus, causing eczema and contraction of the skin.

Treatment.—During the healing of injuries, burns, or in the course of bone disease, to prevent Ectropion as far as possible it may become necessary to keep the lids closed sometimes for two or three months. This is done by the application of strapping, or in cases requiring a prolonged treatment, by producing (temporary) adhesion of the margins of the eyelids.

In slight cases of ectropion, and in those which arise from expansion or relaxation of the tarsus, or from paresis or paralysis of the orbicularis muscle, the palpebral aperture is narrowed by operation. In extreme cases we may have to perform the same operation at the inner canthus also, taking care not to disturb the tear puncta.

Ectropion arising during acute inflammation of the conjunctiva often subsides spontaneously. During the inflammation the lids can be maintained in position by the application of metal sutures, pieces of strapping, or a bandage.

In ectropion following incisions through the eyelids we remove the cicatrised edges of the everted lid, and carefully unite the wound.

Ectropion from cicatrices, or from destruction of the skin (in consequence of abscess, diseased bone, &c.), is usually observed at the outer and lower, or at the outer and upper, margin of the orbit.

If the cicatrix is circumscribed and close to the outer or inner canthus, and all parts of the lid are destroyed, and if the V-shaped incision is thought inadmissible, we remove the cicatrix and transplant some of the adjoining skin. The "formation of a new eyelid" (i.e. the transplantation of skin from adjoining parts) becomes necessary if the skin of the everted lid, or all the textures of the lids, are destroyed, or changed into an unsightly cicatrix.

Ectropion from extensive cicatrices may be remedied by temporary apposition of the margins of the eyelids, the canthi *being left intact.* An incision is carried down to the bone parallel with the margin of the orbit, and about a quarter of an inch from the cicatrix. The skin and cicatrix are then separated from the parts to which they are adherent to such an extent as to allow the lid to be brought as nearly as possible into normal position. The margins of the lids are then brought together by sutures. The lids are separated again as soon as there is no longer any danger of the cicatrix contracting.

Operation for Ectropion caused by small cicatrices, part of the margin of the lid being in contact with, or adhering to, the margin of the orbit.

The cicatrix is circumscribed by an elliptical incision, separated from the surrounding skin, and removed by dissection. The surrounding skin is then sufficiently separated from the soft parts beneath it to allow the lid, without stretching, to be brought into normal position. It is maintained in this position by strapping, or by temporary union of part of its margin with a corresponding part of the margin of the other eyelid. The elliptical incision is closed by sutures. The skin having become adherent to the spot from which the cicatrix has been removed, we allow the lids to open again.

Ectropion caused by large or small cicatrices, and treated by the V-incision.

An incision is carried from near the outer edge of the margin of the everted eyelid along one side of the cicatrix, through the skin and soft parts down to the bone, or, at all events, to a greater depth than the cicatrix itself. A similar incision is made along the other side of the cicatrix to meet the first at an angle. The two incisions together form the V-incision, the base of which is at the margin of the lid. In fat persons, much shrinking of the flap must be expected: the incisions, therefore, have to be made at greater distances from the cicatrix; in other words, the V must be made larger. The parts enclosed by the incisions, especially the cicatrix, are thoroughly dissected away from the periosteum, or from the soft parts not implicated. The dissection is carried from the apex towards the base of the V until the margin of the lid can with

ease be brought into a natural position. It is maintained in this position by strapping, or by the temporary union of the corresponding margins of the eyelids. The edges of the wound are united by sutures which are applied first near the point where the two incisions meet. The more completely the wounded surface is covered with skin, and the less stretching there is of adjoining parts, the less likely is it that the Ectropion will return.

A few sutures applied to the sides and apex of the flap may assist in keeping it and the lid in a good position. Entropion immediately after the operation, from the flap being apparently too large, may be considered favourable. The line of union resembles the letter Y after the operation is terminated.

Operation for Ectropion caused by destruction of a small portion of the lower lid near the outer canthus, a cicatrix occupying the place of the destroyed portion of the eyelid.

The cicatrix is circumscribed by a V-shaped incision, and dissected away. A flap sufficiently large to cover the wound easily is then cut from the skin close to the triangular wound. This is effected by carrying an incision from the wound outwards beyond the outer canthus, and from the end of this a second one downwards, and parallel with the nearest margin of the wounded surface. The flap is dissected off and displaced so as to cover the surface from which the cicatrix has been removed; it must, however, remain connected with the adjoining skin by a broad base. It is fixed in its new position by sutures.

Sloughing or shrinking of the flap, or of part of it, may leave a red nodular swelling. This arises from undue stretching of the flap, or from its base not having been made large enough.

Formation by operation of an entire eyelid, or of part of an eyelid.

We first ascertain whether any part of the eyelid remains. Though the skin and muscular tissue may have been destroyed, we often find that the tarsus, or part of it, with some altered conjunctiva, has been preserved. In such case we free the distorted or everted tarsus from adhesions, place it in a natural position, and unite it by sutures with the opposite eyelid. The union is maintained until the tarsus is covered with cuticle, and all tendency to contraction has disappeared.

Cases of supposed complete destruction of the upper lid, in which large and deep cicatrices over the forehead and temple rendered the success of transplantation of skin very doubtful, have thus recovered, with preservation of sight, and useful upper lid.

In transplanting skin from adjoining parts on to the replaced tarsus,

or in forming an entire eyelid out of transplanted skin, the following rules should be observed :—

(1.) For a lower lid, the skin should be taken from near the ear; for an upper lid, from the forehead and temple; and, in either case, from a part as near as possible to the spot where it is wanted.

(2.) The portion of skin to be transplanted should be as sound as can be obtained.

(3.) The flap of skin should be considerably larger in all its dimensions than the surface we wish to cover. The shape of the desired eyelid should be traced on paper, cut out and placed upon the part from which we propose to take the flap. We then mark upon the skin an outline similar to that of the paper, the lines running parallel with the margins of the paper, but describing a space which, as regards size, is at least as large again as the paper. The skin flap in fat persons should be still larger.

(4.) The base or bridge which connects the flap with the surrounding skin should be broad. The flap, however, should have sufficient mobility to allow of its being sufficiently displaced without being too much stretched.

The flap is secured in its new position by sutures, and the after treatment conducted upon general surgical principles. Warmth should be applied if the flap has been taken from anæmic cicatrised skin; cold, if the swelling and redness are considerable, and the sensation of cold is pleasant.

SYMBLEPHARON.

Symblèpharon signifies adhesion of the conjunctiva of the eyelid to that of the eyeball.

We distinguish—

(1.) *Anterior Symblepharon*, i. e. adhesions of the conjunctiva of the lids to different parts of the surface of the eyeball, by means of vascular or non-vascular bands. The entire conjunctiva of the lower lid may be found adherent to the eyeball. The conjunctiva of the upper lid is rarely adherent throughout.

Extensive adhesions of this kind have been separated successfully by means of scissors and a grooved director. If the entire conjunctiva of one or both eyelids is adherent to the eyeball, a stout lead wire should first be thrust through the adhesions in the direction and situation of the fornix of the conjunctiva. This is left until the walls of the channel thus formed among the adhesions have become cicatrised. It is then withdrawn, and the rest of the adhesions are divided by means of scissors. The lids are kept everted by a suture or bandage until the wounded surface has become cicatrised. It may become necessary to split the outer canthus in order to produce and maintain a more complete temporary eversion of the lids.

Bands extending from the margins of the lids to the eyeball are dissected from the latter, and a needle armed with silk is passed through those portions which were attached to the eye. The needle is carried through the lid from within outwards, close to the margin of the orbit, and the silk is fixed upon the skin. The band is thus drawn in the same direction, and its smooth surface is caused to lie next the eye. In this manner re-union is prevented.

If this mode of treatment cannot be adopted, the band is divided close to the eyeball. After cicatrization of the wound, the edges of which must be prevented from re-uniting, the band is removed from the lid unless it has shrivelled away spontaneously. If the cornea is implicated, an opacity may remain; though opacities occupying half of the surface of the cornea may gradually disappear after removal of the adhesions.

Syncanthus signifies a symblepharon at the inner canthus, complicated with destruction of the caruncle and of the semilunar fold.

(2.) *Posterior Symblepharon,* i.e. shortening of the conjunctiva caused by shrinking of the fornix alone, or by adhesions between the fornix and the adjoining palpebral and ocular conjunctiva, is of no consequence if slight. If extensive, it impairs the mobility of the eyeball, gives rise to entropion, &c. It is at present considered incurable.

Anchylo blepharon signifies adhesion of the margins of the lids to each other, by means of membranous bands extending from the edges of one eyelid to those of the other. This generally occurs at or near the outer, rarely at the inner, canthus. The adhesion may be divided, and the wounded surface, after bleeding has ceased, painted over with collodion.

Anchylo symblepharon signifies adhesion of the margins of the eye-lids to each other, and to the ocular conjunctiva.

Blepharophymosis signifies *narrowing of the palpebral aperture.*

The outer palpebral ligament and the other parts which contribute to the formation of the outer canthus appear thickened and often inflamed. The causes are:—shrinking of the conjunctiva after injuries, after loss of the eyeball, after protracted tinea, and especially after protracted granular ophthalmia with pannus.

Blepharophymosis gives rise to entropion, eczema, and epiphora, and to more or less Blepharospasmus.

Operation for Blepharophymosis (*Enlargement of the contracted aperture of the eyelids*).

The eyelids are kept open by a strong wire speculum, and the outer canthus is thus put on the stretch. With scissors, or with a scalpel, a horizontal incision about half an inch in length is carried through the outer

canthus, outer palpebral ligament, and orbicularis muscle, down to the outer angle of the orbit. The edges of the incision are then drawn widely asunder, and the conjunctiva is united by sutures to the nearest portions of skin.

Some of the conjunctiva is thus interposed between the fibres of the orbicularis muscle, and slight ectropion is produced.

Tarsoraphy.—*Union by operation of any portion of the margin of the tarsus of the upper to that of the lower lid.*

The tough texture of the tarsus, the great pain felt on wounding it, and the profuse bleeding which always occurs, render it advisable to administer chloroform.

With a sharp cataract knife, or better, with a bent lancet-shaped knife, we remove from the upper and lower lids those portions of the inner edges of the tarsi which lie opposite to each other. None of the eyelashes need be removed. The wounded parts, when the lids are closed, should be opposite each other. The lids are united by passing a suture beneath the wounded surfaces, the needle being carried close to the margin of the wound through the conjunctiva, tarsus, and skin.

The lids of both eyes are kept closed and at rest for thirty-six hours, when the sutures may be removed.

The inner and outer canthi and any portions of the margins of the lids may be thus united.

INJURIES.

Wounds.—The cut edges of a wound however large, if fresh, or not yet granulating, should be carefully united by sutures. Care should be taken to prevent the tear puncta from becoming closed or displaced, if the wound should happen to be near them.

If the wound is already granulating, strips of sticking plaister should be applied so as to secure a natural position of the lid while the wound is healing. Any displacement of the lid is to be remedied afterwards.

Ecchymosis, or suffusion of the lid with blood, whether the result of a blow, of leech bite, or of an operation, should be treated by the application of a poultice made of the scraped root of black bryony (Bryonia Nigra), mixed with equal proportions of linseed meal, or bread crumbs. The poultice, spread between pieces of linen, is placed upon the closed lids, and left on as long as the patient can bear it. Several poultices may have to be applied in succession. Ecchymosis of the lids, following excision of the eyeball, causing extreme swelling and discoloration of the lids, disappears completely, after applying such poultices for from one to three days. An "almost unbearable stinging sensation" accompanies the disappearance of the suffusion.

Some recommend fomentations with hot water instead of the poultice.

Emphysema of the lids results from fracture of the bony walls of the nasal cavity, with laceration of the lining membrane. The air passes beneath the skin of the lids when the nose is blown. When this is done the lids become suddenly swollen, without changing colour. On percussion a clear sound is heard, and on touching with the finger a crackling of air is felt as when squeezing an emphysematous lung. Lint with cotton wool is applied over the closed lids, so as to cause slight pressure, and the parts are kept at rest for some days.

CHAPTER III.

THE LACHRYMAL ORGANS.

ANATOMICAL AND GENERAL REMARKS.

The Tears.—The fluid which moistens the surfaces of the cornea and conjunctiva is secreted partly by the lachrymal gland, and partly by the conjunctiva itself, but principally by the latter. The secretion of the lachrymal gland under ordinary circumstances contributes very little towards the moistening of the cornea.

The surface of the eye continues moist after complete removal of the lachrymal gland. The greater importance of the secretion of the conjunctiva is thus shown.

The tears while passing over the cornea and conjunctiva mix with the secretion (epithelium, &c.) of these surfaces. The tears only flow during unusual excitement of the nerves; and if secreted in too great quantity irritate the eye. Pure tears are feebly alkaline, and have a saltish taste. Their specific gravity at 68° Fahr. is 1.0056.—One hundred parts contain 98.223 water, 0.504 albumen, 0.016 salts (carbonate, sulphate, and phosphate of lime and magnesia, chloride of sodium), and traces of fat.

The tears are pressed on towards the lachrymal puncta by the act of winking. The more frequently this act is performed the more quickly the tears are carried off.

Closure and opening of the eyelids. The act of winking.

The portion of the margin of each lid between the lachrymal punctum (the punctum not included) and the inner canthus changes in form and position during the closure of the lids. The different portions of what is described as the orbicularis muscle do not contract simultaneously. In the act of closing the eye, the lower lid is drawn inwards and upwards; the portion near the inner canthus being raised to a level with the upper

margin of the caruncle, and drawn towards it: the upper lid is drawn inwards and downwards until it meets the lower one: the caruncle and semilunar fold for a moment are hidden from view, and the skin near the inner canthus is wrinkled. The portion of the margin of the lid which encloses the tarsus does not change its form, it simply moves upon the eyeball. The fornix of the conjunctiva of the upper lid approaches that of the lower; while simultaneously the conjunctiva along the tarsal margins of the lids is pressed against the eyeball by the action of the corresponding fibres of the orbicularis muscle (the so-called musculus lachrymalis anterior).

An open space is supposed by some to exist between the lids and the eyeball (i.e. between the palpebral and ocular conjunctiva), which is said to be larger near the inner, and smaller near the outer, canthus. On closing the lids, the inner edges of their margins being in apposition with the eyeball, the smaller space is said to be compressed first, the tears being thus driven over the surface of the cornea and conjunctiva towards the larger space near the inner canthus, and thence into the lachrymal puncta. The tears next pass through the lachrymal canaliculi into the lachrymal sac, and thence into the nasal duct and nasal cavity.

The lachrymal sac, during closure of the lids, is dilated by fluid passing into it. The muscular fibres which are attached to the outer aspect of the anterior wall draw this wall forwards, and thus, as it were, suck the tears into the sac. In cases of fistula of the lachrymal sac the fluid in the fistulous opening can be seen to rise at the moment of closing the lids; and to recede when the lids are reopened.

On opening the eyelids, the muscular fibres acting upon the sac become contracted, and the inner palpebral ligament is drawn towards the eyeball; and thus the sac is supposed to be emptied, the tears escaping into the nasal duct, and thence into the nasal cavity. The conveyance of the tears is probably assisted by the changes which the air in the nasal cavities undergoes during inspiration.

If we suppose the act of closing the eyelids to drive the tears into the lachrymal sac, and that of opening them to force the tears into the nasal duct and into the nasal cavity, we must assume the existence of a mechanism which on opening the lids closes the lachrymal puncta, canaliculi, and sac in such succession as to prevent regurgitation.

The pressure of the orbicularis muscle in the act of closing the eyelids seems to be the chief means of removing the tears.

The tears for purposes of experiment may be coloured by instillations of a decoction of cochineal.

The Lachrymal Gland.—This gland is about the size of a small filbert. It is situated behind the outer and upper margin of the orbit, and under ordinary circumstances cannot be felt through the skin. The surface of the

gland nearest the eyeball is concave; part of this concavity is occupied by a small second lachrymal gland, which causes the conjunctiva of the fornix to bulge slightly. The first branch of the ophthalmic artery, and the lachrymal nerve, which is a branch of the first or ophthalmic division of the fifth nerve, together with a filament from the fourth nerve, supply the gland.

The orifices of from eight to twelve of the ducts of the gland open on to the outer and upper third of the fornix of the conjunctiva, and two more on to the conjunctiva of the lower lid near the outer canthus.

The Lachrymal or Tear Puncta are small orifices, one being situated in the inner angle of the tarsus of each upper and lower eyelid. These orifices lead into the lachrymal canaliculi. The puncta are capable of being contracted or dilated. If not acting they are open and in contact with fluid in the inner canthus. On closing the lids the puncta are drawn backwards, the lower approaching the upper one, and are brought into the best position for receiving the tears. The orifice of the punctum of the lower lid is wider than that of the upper one, and is thought by some to be a little nearer to the cornea.

The Lachrymal Canaliculi sometimes enter the sac separately, sometimes they unite before doing so. They enter the sac behind, and on a level with the inner palpebral ligament. When the palpebral aperture is drawn outwards the direction of the canaliculi is straightened. They are surrounded by muscular fibres (from Horner's muscle), which, when contracted, close them together with the puncta.

Some describe the fibres of Horner's muscle as arched towards the canaliculi, and the latter as becoming expanded during contraction of the muscular fibres.

The Lachrymal Sac and the Nasal Duct. These organs form a continuous tube, the length of which varies from one inch to one inch and a quarter. Near the upper extremity of this tube a circular fold of mucous membrane is found. The portion of the tube above this fold is described as the lachrymal sac, and that below as the nasal duct. The diameter of the nasal duct varies from three-quarters of a line to one-and-three-quarters of a line. It is much wider in old than in young persons. It passes downwards, outwards, and backwards; its course is not quite straight, but somewhat curved, with the convexity of the curve directed forwards. It is surrounded by bone, while part of the sac is extensible, being covered by skin, &c. Mucous membrane, enclosing numerous mucous follicles, lines the sac and the nasal duct. The upper end of the sac projects more or less (generally from a line to a line and a half) above the level of the palpebral ligament. The canaliculi enter the sac behind the palpebral ligament; which latter is firmly adherent to the sac, to the conjunctiva, and to the lachrymal caruncle. The fibres of Horner's muscle arising from the vertical ridge of the os

unguis are adherent to, and pass over the anterior surface of, the sac ; on reaching the lachrymal canaliculi these fibres split up into two portions, one of which surrounds each of the canaliculi and passes on to form a sphincter round its lachrymal punctum, and to become attached to the adjoining portion of the tarsus. Horner's muscle is supposed to be innervated by the fifth nerve, while the orbicularis is supplied by the seventh ; and thus an antagonism is thought to exist between the two muscles.

A series of muscular fibres (part of the orbicularis palpebrarum), arising from the internal palpebral ligament in front of the lachrymal sac, passes among the roots of the eyelashes, and along the anterior free margin of each tarsus, towards the outer palpebral ligament, having numerous attachments to the skin of the lid. These fibres are described by some as the musculus subtarsalis, or lachrymalis anterior. They press the margin of the tarsus against the eyeball. Other muscular fibres arising from the os lachrymale behind the lachrymal sac and passing outwards to lose themselves on the tarsus are termed musculus lachrymalis posterior.

The lower orifice of the nasal duct lies from three to five lines from the floor of the nose, and from three-fourths of an inch to an inch from the nostril. It is from one to two lines wide. Its situation varies according to the length of the nasal duct ; sometimes it lies quite near the floor of the nose. A fold of mucous membrane, called a valve, is generally found on the inner wall of the duct at the lower orifice ; it is placed in such a manner that it can close the duct ; it varies much, and is hardly perceptible if the orifice is situated high up in the nasal cavity ; it is large and thin when the orifice is low down. The orifice is supposed by some to be open during inspiration, allowing the tears to run off, and to be closed by this valve during expiration. Others believe the valve to be always open. In old persons it is frequently missing, or perforated, or too large. Numerous smaller folds of mucous membrane are found higher up in the nasal duct.

There is always some fluid in the duct mixed with an albuminous viscid secretion. Tears can enter the sac when the lower orifice, or even the entire duct, is closed, as may be seen by their escaping through fistulous openings.

DEVELOPMENT.

Little is known respecting the development of the lachrymal organs. The gland and the sac can be recognized during the fourth month of fœtal life ; about the middle of the fifth month the lachrymal puncta and the caruncle are perceptible. At the end of the fifth month the puncta are found permeable.

CONGENITAL ANOMALIES.

Absence of one, or several of the lachrymal organs has occurred in cases of congenital absence of the eyeball.

One sac,—the nasal duct,—the canaliculi and the puncta, have severally been observed to be wanting. Sometimes the canaliculi have been present, although the lachrymal puncta have been absent. One punctum with two canaliculi; two puncta (in the lower lid), leading into one canaliculus; two puncta with a separate canaliculus to each, in the same lower lid, and with traces of a margin of a second lower lid,—have been met with. A cleft of the walls of one (the right) lower canaliculus extending from the punctum to the caruncle, and thus exposing a portion of the inner aspect of the canaliculus, has been observed. In this case the edges of the cleft were slightly and equally apart, pale in colour, and rounded off as in hare-lip; there was no epiphora.

Dilatation of one lachrymal sac and lachrymal fistula have also occurred as congenital affections.

MORBID CHANGES OF THE LACHRYMAL ORGANS.

THE LACHRYMAL GLAND.

Enlargement of one lachrymal gland or of both rarely occurs. The presence of a tumour in or near the situation of the gland may lead us to suspect the gland to be the seat of the tumour.

Enlargement of the gland, or some tumour near it, together with accumulation of blood in the orbit, may cause considerable protrusion of the eyeball. When chronic enlargement of the gland causes displacement of the eyeball, with impairment of vision, the removal of the gland is necessary.

A preparation in the Eye Infirmary, Moorfields, shows adhesion of an enlarged lachrymal gland to the nearest part of the sclerotic. In the gland a cyst was found which communicated with the interior of the eyeball. Enlargement of the cells of the gland, and albuminous fluid within the cyst, were discovered on minute examination. In cases of morbid changes in the gland lachrymation is the exception.

A short time ago a patient attended at Guy's Hospital, suffering from sudden and simultaneous enlargement of both lachrymal glands. They were painful to the touch, and about three times the usual size, but of good shape. They resumed their normal appearance in about three weeks, under the administration of Iodide of Potassium.

Swelling of the gland and of the adjoining portion of the eyelid is sometimes observed after operations in the neighbourhood. Shrinking of the gland, abscesses, caries of the adjoining bones, protrusion of the eyeball with suppuration of the cornea, or of the entire eye, and fistula, have followed inflammation of the gland. Cancer and syphilitic enlargement have occurred.

Cysts in the lachrymal gland, or in one of the ducts passing from the gland to the fornix of the conjunctiva, so called Dacryops, and fistula of the gland, or of one of its ducts (Dacryops fistulosus).

This affection may be congenital. Obstructions of the ducts of the gland in consequence of abscesses, wounds, or operations in the neighbourhood, have given rise to the formation of cysts. In such cases the cyst has formed a small elastic tumour beneath the outer and upper part of the upper lid, which on shedding tears has suddenly become larger. The cyst may attain a large size and extend backwards along the eyeball, with the movements of which it may interfere; or it may cause protrusion of the eye.

Treatment.—The thinness of the walls of the cyst generally render its entire removal difficult. If opened through the skin a fistula may remain. The best plan is to establish a permanent fistulous opening upon the adjoining conjunctiva. See p. 75.

Fistula of the lachrymal gland.

A fistula of this gland, or of one of its ducts, is recognized by oozing of tears from a small aperture in the skin of the upper lid near the outer canthus. If there be a cyst communicating with the fistula, it can often be emptied by pressing it against the outer border of the orbit.

Sometimes the fistula opens on the conjunctiva, and on everting the lid a small bluish cyst may be seen near it. This opening may become closed accidentally, and numerous attacks of ophthalmia with chemosis near the outer canthus, or an abscess and swelling of the lids, may appear. The symptoms subside if the fistula opens again. Such a fistula has been known to exist for nineteen years. It annoys the eye, and wind and dust give rise to excessive secretion of tears.

Treatment.—A fistulous opening should be established through the adjoining conjunctiva, and the fistula in the skin afterwards closed. See p. 75.

THE LACHRYMAL CARUNCLE.

A small red tumour attached by a pedicle to the surface of the caruncle has been removed by operation. It consisted of caudate cells and connective tissue; the caruncle itself was healthy. In another case a tumour resembling in structure the Meibomian glands was removed. This was attached to the caruncle by a broad base, and was unusually red and slightly uneven, with minute yellow dots (the orifices of the ducts of the glands). It had fine hairs projecting from its surface.

INFLAMMATION OF THE LACHRYMAL SAC.

From some cause or other acute inflammation may appear in the region of the lachrymal sac. Sometimes, but less frequently, both sacs are simultaneously affected.

General illness, syphilis, disease of the surrounding bones, erysipelas, pus from the conjunctiva, morbid changes in the mucous membrane of adjoining cavities and chronic morbid changes of the sac itself, may give rise to this affection.

An abscess in the neighbourhood of the lachrymal sac, simulating inflammation of the sac itself, is termed *anchylops* before, and *ægilops* after, perforation has occurred.

An early symptom of inflammation of the lachrymal sac is the appearance of a hard, red, generally very painful, ill-defined, and sometimes erysipelatous swelling in the region of the sac. It is in few cases only that the hard inflamed sac can be felt through the skin as a well-defined tumour. The swelling forms rapidly. Headache and general feverishness may precede it. The eyelids are more or less swollen and red, sometimes so much so as to prevent their being raised. Dryness of the corresponding side of the nose, or clear discharge from the nose, may be present. The inflammation rarely passes off without disturbing the functions of the lachrymal passages.

On pressing on the acutely-inflamed sac little or nothing escapes. As the inflammation and the swelling of the mucous membrane decrease, pus appears in the puncta on pressure, or through a fistulous opening. The acute inflammation reaches its height in the course of a few days. If an abscess forms it perforates the skin, as a rule, just below the internal palpebral ligament. A fistula, termed fistula of the lachrymal sac, often remains, through which pus, mucus, or tears may escape. With or without such a fistula, there may remain purulent or mucous discharge from the sac, and chronic inflammation with strictures in different parts of the lachrymal passages.

Treatment.—The general treatment depends upon the cause of the inflammation, and upon the health of the patient. At the outset of the inflammation we apply one or two leeches to the skin over the sac, and afterwards pieces of lint dipped in cold water. If the lids and the skin over the sac are already swollen, fomentations with hot water, or with hot poppy-head lotion, during the day, and a poultice over the inflamed sac at night, are indicated. If fluctuation is felt, a small incision may be made into the most prominent part of the swelling, to allow the pus to escape; the incision is kept open by occasionally passing a blunt probe into it. Hot fomentations are repeated frequently, and the patient is ordered occasionally to press gently on the swelling, so as to cause any pus, which may have accumulated, to flow out. As the pain, swelling, and redness of the skin subside, the fomentations may be applied less frequently.

Surgical treatment of the consequences of acute inflammation of the sac may be adopted as soon as the redness and swelling of the parts surrounding the sac have nearly subsided. Eight to ten weeks may elapse before fistula, strictures, &c., can be attended to. It is well to give nature full time

to repair the effects of the inflammation before resorting to operative interference.

After an abscess of the sac has emptied itself, diseased bone must be carefully searched for. If any be found, frequent injections of warm water, or stimulating lotions (of Iodine, Sulphate of Zinc, &c.) must be used, and continue until no more diseased bone remains. Such injections are best made by the patients, who should be taught how to pass the nozzle of the syringe through the incision, or fistulous opening. Perseverance in injecting warm water, followed by astringent solutions, may restore the permeability of the lachrymal passages without requiring the use of the probe.

Ozæna, i. e. fetid mucus, or purulent discharge from the nostrils, with or without escape of particles of bone, is sometimes complicated with fistula of the lachrymal sac. The fistula in such cases frequently communicates with the nasal cavity. Periostitis alone, or caries, may be the cause.

Fistulous openings, with the surrounding skin flabby and dull red, and with fetid discharge, may exist near the lachrymal sac, without communicating with its interior.

Chronic syphilitic affections of the mucous membrane of the nose are often the original cause.

Treatment.—Frequent injections, into the nasal cavity and lachrymal sac, of Lotio Aluminis, alternating with injections of Infusion of Camomile flowers, have sufficed to cure some cases; others have recovered after the removal of polypi. Appropriate antisyphilitic treatment is required in most instances.

DISTENSION OF THE LACHRYMAL SAC.

Discharge from the lachrymal sac.—Tumour of the lachrymal sac.—(Blenorrhœa).

In a case of epiphora we must ascertain, by pressure upon the skin with the finger, whether the lachrymal sac contains mucus, pus, &c.

The distension of the sac may be caused by tears, by clear viscid mucus (Mucocele), by muco-pus, pus, blood, or decomposed blood (a dark brown fluid containing dark red and orange-coloured crystals). The distension first affects the anterior wall, and readily occurs if the nasal orifice of the sac is closed, or not sufficiently permeable.

The morbid contents of the sac sometimes change in character, e. g. during ill health. A more watery discharge may thus become purulent.

The enlargement of the sac varies in degree. The distended sac often appears as a small roundish tumour situated behind, and below the

internal palpebral ligament. Sometimes it is adherent to the skin. When pressed upon, mucus, &c., escapes, generally through one or both lachrymal puncta, or through a fistulous opening, but seldom through the nasal duct.

When the disease appears slowly the patient's attention is drawn to it by the tumour, or the discharge, or by the obscuration of vision, or by the epiphora, or by the tenderness and redness of the adjoining skin. During hot weather the enlargement may be hardly perceptible. External circumstances inducing catarrhal ophthalmia readily cause the discharge to reappear, and *vice versâ*, the discharge escaping from the sac upon the conjunctiva sometimes gives rise to Blepharitis and Catarrhal Ophthalmia.

Occasionally attacks of inflammation occur in the parts around the distended sac.

The discharge is frequently attributed by the patient to a preceding acute inflammation of the sac. The more common causes of the discharge are stricture or complete closure of various parts of the lachrymal passages (with or without fistula), polypi, morbid changes of the mucous membrane of the nose, and granular ophthalmia.

Treatment.—Spontaneous recoveries have occurred. Generally, however, if not treated, the discharge continues for life; and is sometimes associated with great enlargement of the sac, and absorption of the adjoining bones. The enlarged sac may open into the nasal cavity; in which case there may be emphysema of the surrounding parts. Numerous strictures, or even complete closure of parts of the lachrymal passages, caries of the adjoining bones, and chalky deposits in the lachrymal passages, have been observed to follow.

In cases of discharge without much dilatation, both canaliculi, or at least the one through which the discharge escapes when pressure is made upon the sac, should be thoroughly slit open. If the sac is much dilated and its walls are flabby, both canaliculi are laid open, together with the adjoining portion of the sac. For several days a probe is passed, to prevent reunion of the edges of the incision.

The patient is directed to empty the sac frequently by pressure. In doing this, care should be taken to compress the sac in a direction from the eyeball towards the nose, so as to cause the discharge to escape as much as possible by the nasal duct. The orifice of the duct is generally narrowed or closed, but the discharge having an easy escape through the slit-open canaliculi, and the tears better access to the sac, the causes of the closure of the nasal orifice (thickening of the periosteum, mucous membrane, &c.) frequently subside. The walls of the sac become contracted, the discharge changes from pus to mucus, and then to clear fluid, until at last it ceases altogether, and the tears pass off by the proper channel.

If the discharge should not have changed its character within from

three to six weeks after slitting open the canaliculi, nor have escaped through the nasal duct, the treatment for stricture of the nasal duct must be adopted. Some recommend injections of warm water once a day, to wash out the sac, to be followed by an injection of Lotio Aluminis (gr. viii. ad aquæ ℥i.). Such injections are expected to alter the morbid condition of the mucous membrane. If there be much transparent viscid mucus, or much swelling of the mucous membrane of the sac with purulent discharge, as is observed in cases of granular ophthalmia, a solution of Sulphate of Copper (gr. x. to xx. ad aquæ ℥i.) is used for injection.

Careful examination into the causes of the discharge and appropriate general medical treatment materially assist, and sometimes succeed in curing the patient, even without local treatment becoming necessary.

EPIPHORA (WATERING OF THE EYE).

Inflammatory changes, especially of the surface of the cornea and conjunctiva, as also some of the morbid changes of the interior of the eye, are frequently accompanied by profuse secretion of tears. Such a condition is called "*lachrymation.*" The term "*epiphora*" is used when the overflow of tears appears with morbid changes, obstruction, displacement, &c., of the lachrymal passages. The lachrymation accompanying some forms of ophthalmia is due to reflex irritation of the lachrymal nerves. Hardly any lachrymation accompanies inflammation of an anæsthetic cornea. Too great a quantity of tears is in itself a source of irritation to the mucous membranes.

Epiphora is one of the first symptoms of paralysis, or paresis, of the orbicularis muscle, and appears before changes in the position of the lids or lachrymal puncta become manifest.

In a case of paralysis of the third, fourth, fifth, sixth, and seventh nerves, the tears accumulated in the inner canthus, and were not carried off; irritation of the eye resulted. Mental emotions in this case did not cause secretion of tears.

Epiphora usually arises either from impermeability, or from displacement of the tear puncta. A tear punctum when displaced and turned away from the eyeball (everted) often appears dry. Morbid changes of the margins of the lids (chronic blepharitis,—in old persons a relaxed state of the muscles of the lids, &c.) are the most frequent causes of eversion. Swelling around the puncta (their edges being red and turgid), from injury or from inflammation of adjoining parts (during granular ophthalmia, &c.), frequently causes them to become enlarged at first, and subsequently to shrink, or to become strictured, or completely closed.

Foreign bodies (eyelashes, &c.), have been met with in the puncta or canaliculi, causing repeated slight attacks of ophthalmia, and a pricking

sensation about the inner canthus with epiphora. Sometimes an eyelash may be seen projecting from the punctum and may be readily withdrawn; at other times the punctum and canaliculus require slitting open before the eyelash can be removed.

Epiphora generally precedes, and for a considerable time accompanies, obstructions and other morbid changes of the lachrymal passages. Other causes of epiphora are stricture or closure of the canaliculi through injury, sebaceous tumours, fungi, or chalky concretions, or through spontaneous inflammation, ulceration, or morbid changes in the follicles.

Shrinking of the eyeball may produce epiphora by depriving the muscles which act upon the lachrymal passages of their support.

The epiphora varies in degree in the same case at different times, and is worst when the eyes are exposed to the wind. There may be none during a warm dry season.

Lachrymation often causes eczema along the margins of the lids; not so epiphora.

Treatment.—Lachrymation subsides if the morbid changes of the cornea, &c., which gave rise to it are properly treated. Displacement or obstruction of the lachrymal puncta and passages must be attended to, whatever be the cause of the lachrymation.

In all cases of epiphora we must examine the state of the lachrymal passages. To do this a knowledge is required of the method of passing probes, and of injecting fluid into the passages, and of the operation of slitting open the tear puncta and canaliculi.

Water should be injected previously to, and a few days after, the operation of slitting open the puncta. If the injection does not pass, probing of the passages is required, and the case is treated as one of stricture. This may be complicated with fistula, or with discharge from the sac.

STRICTURE OR CLOSURE OF THE LACHRYMAL PASSAGES.

This condition is most frequently met with at the spot where the canaliculi join the lachrymal sac, and at the nasal orifice of the sac (commencement of the nasal duct). It rarely occurs in other parts of the passages. Whatever be the cause or duration of the obstruction, if it is complicated with epiphora, or fistula, or discharge from the lachrymal sac, its removal, as a rule, causes these complications to subside.

The situation of the stricture, or closure, is ascertained by passing a probe through the lachrymal passages, after having previously slit open the punctum and the canaliculus of the lower lid. If the stricture is situated at the spot at which the canaliculus joins the lachrymal sac, it is necessary to slit open the part of the sac immediately adjoining the canali-

culus, and to prevent reunion by passing a probe through the incision into the sac for several days in succession.

Strictures of the nasal duct are treated by slitting open the lower canaliculus, or the one through which the discharge, if there be any, returns from the sac; and by occasionally passing a probe of appropriate size through the canaliculus and nasal duct, and leaving it in for a few minutes.

It generally suffices, when we have once succeeded in passing number six probe, to introduce the probe only when the epiphora becomes troublesome.

If we suspect the obstruction of the nasal duct to be caused by swelling of its lining mucous membrane (e. g. from granulations), slightly astringent injections and the passage of catgut probes (gradually increasing in size), may be tried. For the treatment of stricture of the nasal duct, see treatment of fistula of the lachrymal sac.

"Complete closure" of any portion of the canaliculus is treated by incision with the guarded knife. The edges of the incision are prevented from reuniting by frequently passing a probe.

In complete closure of the nasal duct, a number six probe, introduced into the sac through one of the slit-open canaliculi, is forced into the nasal duct. As long as the probe is pressed on in the right direction, no harm can be done, although much force may be necessary.

FISTULA OF THE LACHRYMAL SAC.

The fistulous opening in the skin, especially if there is no inflammation around it, is small and sometimes hardly perceptible. Its situation is indicated by the occasional escape of a tear through it, either spontaneously or during pressure upon the sac. It generally lies close to the lower margin of the internal palpebral ligament. Sometimes it is lower down upon the cheek, or even near the outer canthus. Sometimes it is situated in the conjunctiva, or opens into the nasal cavity. As a rule, it is preceded by acute inflammation of the sac. It is sometimes caused by injury.

Many cases of suppuration of the lachrymal sac, whether followed by spontaneous perforation, or opened by incision, get well without leaving a fistula.

Treatment.—Unless treated, the fistula may continue for life.

It is generally complicated with one or several obstructions in the lachrymal passages; and as a rule closes spontaneously if the permeability of these passages is restored. This is usually accomplished by "probing," after having in every case slit open the tear puncta and canaliculi (one or both) and adjoining portion of the lachrymal sac.

The treatment by probing should be commenced as soon as the swelling

of the parts surrounding the canaliculi and tear puncta admits of easy access to the latter.

Cases in which the skin has been inflamed over the sac, and the lids swollen, have recovered (with closure of the fistula, cessation of the epiphora, and of the discharge from the sac) within a month after the first passing of a number six probe into the nasal duct.

When probing, or inserting a style, we must be careful to carry the instrument in the direction which the lachrymal passages take in health; and also to open freely, and to keep open, those parts of the passages through which probes have to pass.

After having slit the canaliculi, we at once try to pass number six probe through the lachrymal passages into the nose. If we succeed, we leave the probe inserted for from ten to fifteen minutes. Laminaria probes expand rapidly, through imbibition of fluid, and it may become difficult to withdraw them. We must, therefore, be acquainted with the degree and rapidity of their expansion.

After withdrawing the probe gently, we direct the patient to empty the sac frequently by pressure upon the skin round the fistula, and to apply a small linseed-meal poultice to the inflamed part at bed-time. The probing is repeated every second day, and less frequently if the epiphora and discharge decrease. No poultices are required if the skin is not inflamed.

Some recommend the temporary introduction, through the fistula into the nasal duct, of a piece of catgut probe, saturated with nitrate of silver. One end of the prepared probe is hammered flat, and bent. The bent part is left to project through the fistulous opening, while the rest of the probe is introduced into the stricture until it is firmly grasped.

Previous to passing the probe, and after its withdrawal, the lachrymal sac should be syringed out with warm water. The probe is left in the stricture for twenty-four hours and then withdrawn. A fresh one is introduced every day until the nasal duct has reached its proper calibre, and until an injection into the sac passes through the duct into the nose. This result may be attained within a few weeks. If irritation arises a simple probe is introduced until the symptoms have subsided.

Experience is required as regards the frequency with which the probe should be introduced.

In this we must be guided by the decrease of the epiphora and discharge. If these become less, especially if the fistula has closed, we discontinue probing; if they reappear or continue as before, we probe again. Injections of warm water, &c., through the fistulous opening, or through the canaliculi into the sac—if they should have been thought necessary—are discontinued as soon as no more discharge, but only clear fluid escapes from the sac while injecting.

Though many cases recover by local remedies alone, much benefit may be derived from good general medical treatment. The use of arsenic internally, with the local application of mercury, is especially to be recommended.

INJURIES.

Wounds of the skin and other soft parts near the lachrymal passages must be carefully closed, and the parts kept in such position as will contribute most perfectly towards the undisturbed conveyance of the tears.

Fistulous openings in the lachrymal gland, the canaliculi, or the lachrymal sac and nasal duct, may be the result of injury.

Rupture (e. g. of the lower canaliculus) with closure at the seat of injury may occur. In this case we pass a properly bent probe along the upper canaliculus into the lower one. We then slit open both canaliculi along the probe.

Rupture of the lachrymal passages, by blows, &c., followed by emphysema of the surrounding parts, is not an uncommon occurrence. The swelling of the lids in such cases appears when the patient is blowing the nose. It commences at, and spreads from, the inner canthus. A crackling noise is perceived on making pressure upon the swollen lids, or a full sound on percussion. Rest of the parts, avoiding blowing the nose, and slight pressure upon the spot from whence the emphysema commences, must be recommended.

INSTRUMENTS USED IN THE TREATMENT OF LACHRYMAL OBSTRUCTIONS.

Probes.—Three silver probes (known as Bowman's probes), the ends of each being of different sizes (number one being the smallest, number six the largest size).

A conical probe for closing one tear punctum, while injecting through the other.

Laminaria, and catgut probes of different sizes.

Laminaria probes.—These probes are made from the dried stem of the Laminaria digitata. They cannot be passed so readily as silver probes. Through rapid imbibition of moisture, when passed into the lachrymal passages, they swell out considerably. They have been found of use in cases of stricture of long standing. Large probes may be left in from ten to twenty minutes. An indentation in the swollen part of the probe indicates the seat of the stricture. The dilatation can be confined to the stricture by covering those parts of the probe which we wish not to become distended with copal varnish. With a smaller probe we previously ascertain the seat and extent of the stricture.

Catgut probes.—One end of the probe is rounded off, and the oily

matter washed out with weak liquor potassæ. The part which is to lie in the stricture is dipped into a solution of nitrate of silver (about a drachm to an ounce of distilled water) for from five to ten minutes. The probe is then suspended in a dark place, dried and kept in a blackened glass tube for use. Some dip the probe into a solution of nitrate of silver (one part to ten parts of distilled water) at the time it is required.

Probes of the size and thickness of Bowman's number six probe, but made of *very flexible metal.* These are converted into styles.

A pair of nippers, with a contrivance for bending the flexible probes.

A director of steel, electro-gilt. One end of its firm stem tapers off, and is grooved to within a line of its extremity: the other end of the stem is stronger; its extremity is also grooved, and slightly curved on the grooved side.

A narrow-bladed *cataract knife,* for slitting the canaliculi.

A guarded knife, in shape like a penknife, for slitting open the puncta, canaliculi, and part of the lachrymal sac.

A good *syringe* easily manageable—capable of holding about one fluid ounce, and fitted with nozzles of different sizes, the largest being equal to number six, the smallest to number two of Bowman's probes.

For instruments for cauterizing the lachrymal sac, see Weiss's Catalogue, 1864.

OPERATIONS.

REMOVAL OF THE LACHRYMAL GLAND.

This operation is somewhat difficult if the gland is healthy: it is accompanied by abundant bleeding. The firm connective tissue and fat surrounding the gland may be mistaken for the gland itself; an acquaintance, therefore, with the appearance of its cut surface, when fresh, is necessary in order to avoid error.

During the operation a spatula is placed beneath the upper lid to protect the eyeball.

An incision about an inch long, and commencing near the outer canthus, is carried through the skin, muscles, and suspensory ligament of the eyelid along the margin of the orbit, and over the most prominent part of the gland, if the latter be enlarged.

The gland is seized with a pair of forceps, and separated first from the periosteum, and then from the surrounding tissues.

The amount of suppuration following the operation varies in degree. Erysipelas and considerable swelling of the eyelids, with headache, sometimes occur.

The patient is kept in bed for from three to five days after the opera-

tion, and large pieces of lint dipped in iced water are applied to the wound and surrounding skin. The cicatrix is not conspicuous. The drooping of the upper lid subsides in about seven weeks after the operation. After removal of the gland the eye feels dry; in windy weather more winking is required, and irritation of the conjunctiva is more prolonged and painful.

OPERATION FOR FISTULA OF THE LACHRYMAL GLAND
(*by establishing a fistulous opening in the conjunctiva*).

A strong thread of black silk is armed with a needle at either end. Each needle is passed in turn along the fistulous canal to about the nearest point of the conjunctiva above the tarsus of the upper lid, and then thrust through the wall of the fistulous canal and the conjunctiva. The second needle is made to penetrate the conjunctiva about one-sixth of an inch from the first. A small portion of the conjunctiva and of the wall of the fistula are thus enclosed in a loop, the ends of which are brought out at the outer canthus, and with sticking-plaister secured to the skin of the temple.

If a cyst is present, the needles are passed in a similar manner through the fistulous opening and the canal into the cyst, and then through its walls, and through the nearest conjunctiva.

A few granulations of the conjunctiva round the silk, with some swelling and redness of the lids, must be expected.

About ten days after the introduction of the silk some of the skin surrounding the orifice of the fistula is removed, and the edges of the wound are united with sutures. About the fourth week the silk is withdrawn, and the portions of the wall of the fistulous canal, or of the cyst, as well as of the conjunctiva intervening between the apertures made by the silk, are cut through.

INJECTION OF FLUID INTO THE LACHRYMAL PASSAGES.

To the introduction of the nozzle of a syringe into the puncta and canaliculi, the same rules apply as to the introduction of probes. The size of the nozzle required depends on the nature of the fluid to be injected, and upon the calibre of the canaliculi. Fluid, when injected into permeable lachrymal passages, passes through them, and enters the nasal cavity; and in consequence of the inclination of the floor of the latter, runs backwards into the throat, unless, while injecting, the patient's head is somewhat inclined forwards.

The slightest swelling of the mucous membrane of the lachrymal passages may prevent fluid from passing through. All fluid injected through the lower canaliculus returns through the upper one upon the conjunctiva, if the canaliculi communicate before entering the sac, and the orifice

into the sac itself is closed; or if any obstruction exists at the nasal orifice of the sac. The fluid returns through the canaliculus into which it has been injected if no communication exists between it and the other one, or between it and the sac, or between it and the nasal duct.

While injecting medicated fluids the upper lachrymal punctum must be kept closed by a conical probe introduced into it in order to prevent escape of the fluid on to the conjunctiva.

The injected fluid readily fills the sac if the obstruction exists only at the nasal orifice. In such cases more concentrated fluids may be injected.

Injections may render probing unnecessary. They enable us to recognize the seat of obstructions. They are especially used for the purpose of washing out a distended lachrymal sac, or to induce changes in the nature of its secretion.

THE OPERATION OF SLITTING OPEN THE LACHRYMAL PUNCTUM AND CANALICULUS.

The patient, seated, rests his head against the chest of the operator, who stands behind. During the manipulations care must be taken to keep the margin of the eyelid, and the canaliculus which is to be slit open, on the stretch.

To slit open the canaliculus of the right lower eyelid, the little finger of the left hand, placed upon the skin near the right outer canthus, draws the latter outwards. The margin of the lower lid and the canaliculus are thus stretched over the eyeball. By a gliding up and down movement of this finger some rotatory movement is communicated to the lachrymal punctum, everting it more or less, and enabling us to present it to the grooved director. With the right hand the director is passed into the aperture of the punctum, and then gently pushed on in a horizontal direction, and made to glide through the canaliculus until it is arrested by the inner wall of the lachrymal sac. It is then transferred to, and held in position by, the forefinger and thumb of the left hand. With the right hand a narrow-bladed cataract knife is thrust along the groove of the director, and the tear punctum and canaliculus are slit open on the aspect of the conjunctiva nearest the eyeball, and a little beyond the margin of the caruncle. The little finger of the right hand keeps the upper lid raised, while the thumb, middle finger, and forefinger hold the knife. The knife should not be used until the lid and canaliculus are well secured. The bleeding which follows the operation readily subsides. A fine probe has to be passed once a day for five days, along the slit-open canaliculus, to prevent reunion of the edges.

The operation of slitting open both the puncta and canaliculi, together with the adjoining portion of the lachrymal sac.

The incision made when slitting open the canaliculi is carried as close up to the lachrymal sac as possible. The lids are then kept open, and the soft adjoining parts of the inner canthus expanded by a strong wire speculum. The guarded knife is introduced through one of the slit-open canaliculi (say the lower one) up to the stricture or obstruction. The guard is withdrawn, and the knife thrust through the stricture in the direction of the canaliculus, into and across the lachrymal sac, until its point touches the bone. The incision is then enlarged upwards to the extent of about one sixth of an inch, in a direction to meet the slit-open canaliculus of the upper lid. The guard is then pushed forwards again and the knife withdrawn.

The incision is kept open by passing a probe through it into the sac for several days successively.

PROBING THE LACHRYMAL PASSAGES.

Fine probes may be readily passed through the tear puncta, the canaliculi, the sac, and the nasal duct, without slitting open the puncta.

The canaliculi admit probes of considerable size. Sometimes a difficulty arises from the puncta appearing completely effaced. Their situation at the inner corner of either tarsus, and nearly opposite each other, assists in finding them. These corners become very conspicuous when tilted forwards, while the patient attempts to close the lids. Before passing a probe, the lids, puncta, and canaliculi have to be steadied, as during the operation of slitting open the tear puncta and canaliculi.

A probe, after having been introduced gently and vertically into the punctum, or slit-open punctum, and canaliculus, is pushed horizontally along the canaliculus until it is arrested by the bony wall of the sac. Then, while pressing the one end of the probe moderately against this wall, the other end is raised along the upper margin of the orbit, until it assumes the (nearly vertical) direction of the nasal duct. The part of the probe which rests against the bony wall of the sac, during this manipulation glides along that wall, and spontaneously, or on moderate pressure, enters the nasal duct. When the probe is introduced properly, its projecting portion rests against the upper margin of the orbit, near the supraorbital notch. If this portion of the probe is loose, and stands away from the margin of the orbit, the introduced portion being directed too much backwards, then the lower end of the probe has pierced the lachrymal bone, and has passed behind the nasal duct. This accident is of no consequence if the subsequent probing be carried on in the right direc-

tion. We can tell by the extent to which the probe has entered whether it has passed through the entire length of the nasal duct.

Probing the nasal duct should be practised on the dead body for the purpose of gaining experience as regards the amount of pressure necessary to pass probes of different sizes without injury to the parts. A very prominent supraorbital margin requires an unusual bending of the probe to allow of our passing it into the nasal duct.

When examining for stricture we first slit open generally the lower punctum and canaliculus, and immediately after this, introduce a number six probe along the canaliculus, to ascertain its condition. The canaliculus must be kept well stretched while doing this. If there be a stricture and the probe cannot be passed into the sac, finer probes must be tried. If no probe can be passed, we prevent the incision of the slit-open canaliculus from closing, and wait for from two to three weeks until all irritation and swelling from the operation have subsided.

The canaliculus is permeable and the point of the probe is in the lachrymal sac, if the skin over the sac and the palpebral margin remain motionless (the canaliculus being well-stretched) while the point of the probe is repeatedly pushed towards the inner bony wall of the sac.

Any resistance encountered by the probe, while passing along the canaliculus, causes the skin beneath the internal palpebral ligament to appear wrinkled. The free margin of the lid, though held on the stretch, also becomes pushed towards the lachrymal sac, when the probe is pressed against the resisting portion of the canaliculus (stricture, &c.). It is important to recognize this movement of the lid, and to estimate its extent. Its existence is a certain sign that the probe has not entered the lachrymal sac. If a fine probe passes, thicker ones will gradually be admitted.

We discontinue probing when number six can be passed; and teach the patient to pass the probe, or do it again ourselves, if the epiphora reappears.

With stricture in the canaliculus, others may exist in the nasal duct. If an injection does not pass through the nasal duct, but the probe enters the sac, we pass it on into the nasal duct. If we do not succeed the first time in doing so, it is well to be satisfied with keeping open the punctum and canaliculus, and to wait two or three weeks before trying again to pass the probe.

If the epiphora becomes less, or ceases, as often occurs in stricture after the canaliculus has been freely laid open, no probe should be passed into the nasal duct. The nasal duct is most easily probed through the lower canaliculus; and we hardly ever fail in passing the probe, if we carry it in the direction which the duct occupies in health. On finding a stricture, which is generally situated at or near the duct

orifice of the sac, we use that probe which passes with some difficulty into the stricture. When once number six passes readily, we discontinue probing. We only reintroduce the probe if through contraction of the stricture the epiphora becomes troublesome. Some patients learn to pass the probe themselves. No probe should be passed unless we have a definite curative object in view.

INSERTION OF A STYLE.

A probe made of very flexible metal is introduced either through a slit-open canaliculus, or through a fistulous opening of the sac, and passed through the entire length of the nasal duct to the floor of the nose.

At the spot where the probe projects it is bent horizontally and nipped off about a quarter of an inch further on. The probe is thus converted into what is termed a style. The bent part hangs over the margin of the fistula or of the lid, to prevent the style from disappearing in the passages. Patients with considerable dilatation of the sac, with diseased bone round the sac, with old fistulous orifices, and those who have worn the old style, or a tube, are generally not benefited by wearing this style. It may, however, be tried. It is of great use in very hard, or tight, or extensive stricture.

CLOSURE OF THE LACHRYMAL CANALICULI.

Take a silver probe, dip it into pure nitric acid for two or three seconds, and then warm it slightly over the flame of a spirit lamp. This causes a coating of nitrate of silver to form over the warm part of the probe. Introduce the latter into the canaliculus, and withdraw it after about a minute. An adhesive inflammation causing closure of the canaliculus is expected to follow.

DESTRUCTION OF THE LACHRYMAL SAC.

The cavity of the sac is freely laid open by an incision through the integuments, about three quarters of an inch in length, commencing just above the internal palpebral ligament, passing outwards and downwards and running parallel with the nearest portion of the margin of the orbit. If the sac is distended, the incision is carried over its most prominent part. If there is a fistula, it must be slit, and the sac laid open. All discharge is wiped away, and the inner surface of the sac touched with the solid nitrate of silver, or with the actual cautery. The scab formed by the solid nitrate of silver is removed after forty-eight hours with forceps; this must be done thoroughly and carefully, otherwise tedious suppuration follows. Continuous gentle pressure until the wound has healed is made upon the sac by means of lint or wadding, and a bandage. This is taken off twice daily, and the parts are cleaned with warm water. Erysipelas, or

severe inflammation has in a few cases occurred after this mode of cauterization.

In fifty cases of cauterization with the actual cautery, of which notes were kept, no erysipelas or severe inflammation followed.

Irons of a particular shape are used for cauterizing. The eyeball must be protected by a spatula placed between it and the sac, and the latter must be freely exposed, so as to enable the operator to touch it thoroughly. To avoid bleeding, the white hot iron only should be used. The pain is slight.

Cold fomentations are applied until the incision is closed. The patient need not remain in bed for more than twenty-four hours.

Complete destruction (obliteration) of the lachrymal sac has been found beneficial in cases of fistula, in which we have not succeeded in restoring the natural passage for the tears; in cases of extensive disease of the bones round the sac, or of ulcerations within it; of fistulous openings from the lachrymal passages into the nose, and of closure of the nasal duct from cicatrices. The operation should be preceded by closure of the puncta and canaliculi by cauterization. The tears, if this preliminary step is not taken, find their way towards the sac; and mucous discharge from a newly-formed cavity or fistula, &c., may again appear.

CHAPTER IV.

THE CONJUNCTIVA.

GENERAL AND ANATOMICAL REMARKS.

We distinguish an ocular and a palpebral portion of the conjunctiva and the fornix which connects the two. The small fold which projects from the fornix at the inner canthus is termed the semilunar fold. In front of this is situated the caruncle, which consists of sebaceous and hair-follicles.

The conjunctiva is firmly attached to the tarsi. Along their inner edges it is very thin, and consists almost entirely of small papillæ and connective tissue. The papillæ resemble those of the adjoining skin.

Near the cornea the conjunctiva is in closest contact with the sclerotic. Its epithelium is continued over the surface of the cornea.

Unstriped muscular fibres have been found beneath the conjunctiva, and the dilatation of the pupil, so common in catarrhal ophthalmia, is looked upon as the result of reflex action caused by the irritation of their nerves.

The further from the tarsus, the looser is the attachment of the conjunctiva. The free movement of the eyeball becomes impaired in cases in which the loose conjunctiva of the fornix is more or less destroyed, as happens in severe granular ophthalmia.

In childhood the ocular conjunctiva is almost transparent. With advancing age, it becomes somewhat opaque, and blood-vessels appear in it. These vessels anastomose freely with those of the palpebral conjunctiva.

The vessels of the subconjunctival tissue are supplied by the ophthalmic artery, and anastomose freely with those of the interior of the eye.

Many morbid changes of the orbit, and of the interior of the eye, cause overfulness of these vessels.

At the fornix the vessels of the conjunctiva anastomose with those of the lachrymal apparatus, and with those of the eyelids.

The fifth nerve supplies the conjunctiva, sending, however, more nerve filaments into the palpebral portion.

The papillæ of the tarsal conjunctiva are small and cylindrical, and when swollen give to its surface a velvety appearance.

In the fornix they are large and mushroom-shaped, though not so numerous as in the part of the conjunctiva between the fornix and the nearest margin of the tarsus. It is the clear viscid mucus, secreted by the papillæ, which chiefly lubricates the surface of the cornea. The epithelial cells of the conjunctiva are continually and rapidly changing. The superficial ones are flat and polygonal; the deeper ones are roundish or oval.

EXAMINATION.

For the examination of the conjunctiva the patient is seated, and rests his head against the chest of the surgeon, who stands behind.

The conjunctiva of the lower eyelid is brought into view by placing the thumb upon the skin of the lower lid, depressing it towards the margin of the orbit so as to evert the lid, and then directing the patient "to look up."

The conjunctiva of the upper lid may be examined in the following manner.—A probe is placed across the skin of the upper lid about half an inch from its margin, and the lid is persistently and gently pressed upon. At the same time we seize some of the eyelashes, or a fold of skin near the margin of the lid, and draw the lid a little away from the eyeball and then upwards. The upper margin of the tarsus being gently pressed upon by the probe, is made to glide along the curvature of the eyeball. This manœuvre causes the upper lid to become everted; and when the patient looks down, the conjunctiva and the greater part of the fornix are brought into view.

The eyelids may be everted by a practised hand without using a probe. To accomplish this the thumb is pressed upon the middle of the upper margin of the tarsus, and the margin of the lid is thus caused to stand away from the eyeball. The tip of the first finger of the same hand is then placed between the eyeball and the margin of the lid. Then while continuous and gentle pressure is made with the thumb, the upper margin of the tarsus is caused to glide along the curvature of the eyeball, and the lid held between the finger and the nearest part of the thumb is readily everted. This mode of everting the upper lid, if properly performed, causes no pain, and should be frequently practised, inasmuch as it is required in numerous changes of the cornea and conjunctiva.

Lateral illumination, and the binocular miscroscope, with a low power

and reflected light, have rendered great service in the minute examination of many morbid changes of the conjunctiva in the living body.

DEVELOPMENT.

The space behind the folds, which represent the first traces of the eyelids, is occupied by tissue, out of which, among other parts, the conjunctiva becomes developed. The conjunctiva is fully formed about the third month. About the fifth month the margins of the eyelids are adherent to each other, and the conjunctiva forms a closed bag, which contains some clear fluid.

CONGENITAL ANOMALIES.

Absence of one caruncle and a caruncle with long hairs of the colour of those of the eyebrows projecting from it, have been observed.

Tumours of several kinds have been found at birth.

In extreme hypermetropia, the eyeball being very small, a recess of the conjunctiva is often met with at the outer canthus, especially when the eyes converge.

TUMOURS.

Warts and other dermoid tumours are occasionally found attached to the sclerotic.

Pinguicula is the name given to an opaque yellowish-white, roundish, somewhat lobulated substance, about the size of a hemp seed, situated beneath the conjunctiva generally near the outer and inner margin of the cornea, and surrounded by a few enlarged blood-vessels. It resembles a small accumulation of fat, but, when examined microscopically, is found to consist of ill-developed connective tissue. It occurs after middle age. A desire to improve personal appearance may induce us to remove it.

Lipoma.—This term has been applied (*a*), to an unusual accumulation of fat beneath the conjunctiva, between the recti muscles in the equatorial region of the eyeball (most frequently between the outer and upper recti); (*b*), to an accumulation of fat beneath the conjunctiva of the fornix at, or below, the outer canthus. The fat is intimately adherent to the conjunctiva, extends backwards into the orbit, and frequently causes the fornix of the conjunctiva to bulge.

It is observed in children. Some believe it to be the fat of the orbit, causing the conjunctiva to protrude at a congenitally weak portion of the attachment of the eyeball to the margin of the orbit.

If small and not increasing, it is best left alone. To remove it we give chloroform, and make an incision circumscribing the most prominent part of the tumour.

A wedge-shaped portion (the base towards the conjunctiva) is removed, together with the firmly adherent conjunctiva. The wound is carefully closed by sutures. Cold applications and rest of both eyes for ten or fourteen days are required.

Brown or black pigment spots in the conjunctiva where it joins the margin of the cornea are, in dark persons, of common occurrence.

Nævus has been observed upon the caruncle, and in the ocular and palpebral conjunctiva. It must, if enlarging rapidly, be excised or be destroyed by the galvanic current.

The compressorium forceps, to prevent bleeding during the operation, should be applied in cases in which the nævus is situated in the palpebral conjunctiva.

Polypi have been removed from the caruncle and from the semilunar fold.

Cysticercus.—A patient lately attended at Guy's Hospital from whose ocular conjunctiva was removed a semitransparent vesicle about the size of a pea. It was situated in the sub-conjunctival tissue near the inner and lower margin of the cornea. At one spot it was adherent to the slightly vascular conjunctiva. It had only recently been observed, and was becoming larger. Some yellowish fluid escaped on incising the conjunctiva near it. The entire vesicle was removed. A minute white and opaque dot was observed on its surface. On opening the vesicle some fluid escaped, in which were found the head and hooklets of a cysticercus.

Pemphigus has occurred in the conjunctiva of both eyes simultaneously. The vesicles were of the size of large peas, and filled with turbid fluid: the conjunctiva round the base of each vesicle was inflamed. After some months numerous adhesions had formed between the ocular and palpebral conjunctiva, together with pterygium like bands encroaching from the ocular conjunctiva upon the cornea.

Epithelial cancer has occurred primarily in the ocular conjunctiva in the form of infiltration with an irregular nodular dry surface. It has been found to consist microscopically of an agglomeration of epithelial structure with connective tissue. The veins of the surrounding conjunctiva in such cases have been enlarged.

Melanotic cancer, in the shape of freely moveable nodules, not unfrequently occurs in the ocular conjunctiva.

Medullary cancer has not yet been observed primarily.

PTERYGIUM.

The term Pterygium is applied to a somewhat triangular-shaped, tolerably well-defined substance which, moveable with the conjunctiva, projects slightly from its surface. It generally occupies the ocular conjunctiva between the cornea and semilunar fold of each eye. As many as four pterygia have been observed in each eye, their apices encroaching upon the cornea (in a direction parallel with the recti muscles) and meeting about its centre.

In rare cases the triangular shape may be lost in consequence of changes in the cornea. The apex of the triangle is situated at the margin of the cornea, or upon it.

In the latter case it appears opaque, and is imbedded in the cornea.

The base is situated in the ocular conjunctiva, and generally loses itself in the fornix.

The Pterygium microscopically consists of hypertrophied connective tissue, and of blood-vessels. Its vessels diverge from the apex towards the base, and then anastomose with those of the recti muscles.

If nearly transparent, like the conjunctiva, it is termed *pterygium tenue;* if grey, opaque, and vascular, *pterygium grassum.*

Ulcerations and pustular ophthalmia, followed by hypertrophy of the conjunctiva, are mentioned as causes. But the usual cause is not yet discovered.

Pterygium occurs frequently among sailors, and in young persons living in a hot climate. It causes no pain, but if very dense in texture, may interfere with some of the movements of the eyeball.

It is not generally noticed until it encroaches upon the cornea and gives rise to impairment of vision.

Treatment.—The patient, if he object to an operation, may be told, that, unless the pterygium interfere with "sight," it need not be removed; but that a cure cannot be effected without an operation, and that the recovery of vision will be slower the longer the removal is postponed.

The frequent recurrence of the pterygium after removal has given rise to various methods. The transplantation of the apex is the mode generally adopted for fresh cases, as well as for those previously operated upon.

Operation.—The patient being placed on a couch, and the eyelids kept open by the speculum, the *entire width* of the portion of the pterygium close to the margin of the cornea is seized with a forceps; and a cataract knife, its edge directed towards the cornea, is pushed between the surface of the sclerotic and the pinched-up part of the pterygium, and along the surface of the cornea, so as to dissect off the apex thoroughly.

A small oval-shaped piece of conjunctiva is next removed with scissors from near the margin of the cornea, close to the nearest margin of the pterygium. The pterygium is then sufficiently dissected from the sclerotic, to

admit of easy displacement of its apex (or of the part situated upon, or next, the cornea).

A suture of fine silk is passed through the apex, and through the conjunctiva, so that the dissected part of the pterygium comes to lie over the spot from which the conjunctiva has been removed. The silk suture generally comes away spontaneously. Cold-water dressing, closure of the lids, and rest of the eye operated upon, are required for a few days.

INJURIES.

Burns.—The intensity of the inflammation following a burn varies with the chemical composition, and temperature of the substance which may have come in contact with the conjunctiva, and with the time during which it may have been allowed to remain.

Unslacked lime instantaneously changes the conjunctiva into a pulpy, dead-white, sloughing, or necrosed substance which cannot be pulled off. After from eight to fourteen days, a fibrinous exudation occupies the place and gradually changes into a cicatrix. During this change adhesions of the margins of the lids to each other, or of the lids to the eyeball, may occur.

If the sclerotic has been implicated, its dead-white surface may remain visible for several days before granulations appear on it.

If it has been destroyed, a yellowish-white pulpy substance (necrosed sclerotic) is gradually thrown off, and the darkish colour of the choroid may then be seen shining through a thin layer of healthy sclerotic. Granulations, advancing from its swollen margins, gradually cover the exposed sclerotic. After about two months a cicatrix is formed, generally with some opacity in the adjoining cornea. The cornea, if implicated like the conjunctiva, becomes dead-white and opaque.

Metal (melted lead or iron) has been removed from the conjunctiva having been found moulded to the shape of the eyeball.

Treatment.—The entire conjunctiva, especially its fornix, whatever may have been the nature of the injury, should be examined and cleaned gently and thoroughly. Unslacked lime is best washed away with warm vinegar and water. Particles of mortar, iron, &c., if entangled in sloughing or loose conjunctiva, may be removed by cutting away the portions of conjunctiva enclosing them. Portions of discoloured or sloughing conjunctiva, unless they come away readily, need not be removed. A few drops of clean oil should be placed upon the conjunctiva, and the lids should be kept closed with wet lint. Some recommend lint dipped in oil to be placed between the lids and the eyeball.

Adhesions between the ocular and palpebral conjunctiva often follow, if opposite surfaces of the conjunctiva have been injured. Some, to pre-

vent adhesions, insert a glass mask or an artificial eye; others pass a probe twice daily between the eyelids and the eyeball, until a cicatrix has formed.

Patients should be shown how to draw the lids away from the eyeball, and told to repeat this frequently, in order to prevent adhesions.

Stains by Nitrate of Silver.—The stain is situated in the epithelium, and adjoining superficial parts of the conjunctiva.

Microscopically, it consists of an accumulation of opaque, black, and extremely small granules (oxide of silver ?). These are most numerous where the stain is most marked. See p. 92.

Hæmorrhage into the conjunctiva (Ecchymosis), whether from injury, or from spontaneous rupture of blood-vessels, as for example, during coughing, forms a uniform red non-vascular patch, covered by the smooth shining surface of the conjunctiva. It may completely hide the sclerotic from view. It undergoes the changes of colour usually observed.

Spontaneous Ecchymosis, though harmless in itself, is a sign of morbid changes of the blood-vessels in other parts.

OPHTHALMIA (Conjunctivitis, Syndesmitis).

General Remarks.—Before treating of the individual forms of ophthalmia, we must mention some of the symptoms common to several, or all.

(*a*.) *Various kinds of increased vascularity*—"*redness of the eye.*"

We may find increased vascularity of the ocular or palpebral conjunctiva alone; or of the sub-conjunctival tissue, or of the sclerotic also. The vascularity varies in degree according to the stage or nature of the ophthalmia. It may be so great as to completely obscure the colour of the sclerotic ("the white of the eye"). It is, as a rule, most considerable at the fornix.

The blood-vessels, when situated in the ocular conjunctiva, and in the sub-conjunctival tissue, can be made to glide to and fro on gently rubbing the conjunctiva against the sclerotic. Thus we can recognize the share which the conjunctival vascularity takes in the general "redness of the eye." Large varicose vessels, capillaries, and small extravasations of blood, may occur simultaneously.

The vessels belonging to the sclerotic can by somewhat hard pressure be emptied, but not displaced, and the yellowish-white colour of the sclerotic becomes visible.

We distinguish two kinds of "sclerotic redness."

(1.) Delicate pink or red patches, as seen in circumscribed sclerotitis, and in most morbid changes of the iris and ciliary processes.

The term sclerotic zone, or ciliary redness, is used, if this redness

occurs along the margin of the cornea. It indicates an undue vascularity of the parts within, especially of the ciliary processes.

(2.) Large blood-vessels emerging from the interior of the eye, through the sclerotic in the ciliary region, especially in front of the sclerotic insertion of the recti muscles. These vary in number, and may be thin, or large and varicose. They are particularly well marked in chronic glaucoma and in hypermetropic and presbyopic patients, who by using improper, or no spectacles, subject the eyes to much fatigue.

The different forms of vascularity—the ciliary redness, the enlarged vessels emerging in the ciliary region, and the moveable vessels of the conjunctiva, may occur simultaneously, e. g. in a case of presbyopia, if the patient suffers from iritis and catarrhal ophthalmia.

The frequent combination of different forms of vascularity creates a difficulty in the diagnosis of ophthalmia. Different forms of ophthalmia may merge one into the other, as for example, that which commences as catarrhal ophthalmia, may assume a diphtheritic character, and may finally change into granular ophthalmia.

The vascularity of the conjunctiva is generally proportionate to the intensity of the ophthalmia ; yet in severe diphtheritic ophthalmia the vessels may be compressed, and therefore the conjunctiva pale.

The term conjunctival *Lymphangitis* is applied to thick cylindrical cords, resembling varicose veins, which are occasionally observed beneath the surface of the conjunctiva, and which are filled with a clear substance.

(*b.*) *Chemosis* signifies swelling of the vascular conjunctiva and sub-conjunctival tissue. The term, as a rule, is only applied to the swollen ocular conjunctiva, especially the portion which is next the cornea. If severe, the swollen vascular conjunctiva overlaps, and sometimes completely hides the cornea from view, and protrudes between the eyelids, preventing them from being completely closed or opened.

A sensation of pain and heat accompanies even slight degrees of chemosis.

We distinguish between serous chemosis, in which serum and blood escape from an incision, and fibrinous or solid chemosis, in which the conjunctiva is infiltrated with more or less solid inflammatory products (fibrine, lymph, &c.). The former variety accompanies, e. g. deep-seated inflammation of the orbit or eyeball; the latter is observed, e. g. during the acute stage of diphtheritic ophthalmia. The presence of chemosis always indicates a high degree of inflammation.

Œdema (Infiltration of the non-vascular conjunctiva with fluid) is observed in the course of morbid changes at the apex of the orbit, in Bright's disease, and in weak persons during simple catarrhal ophthalmia.

(*c.*) *Swelling and redness* of the eyelids, accompanies severe inflam-

mation of the interior and exterior of the eyeball. As to degree, it may be equally great, whether occurring during suppuration of the cornea or of the orbit, or during ophthalmitis, or with gonorrhœal ophthalmia. Its decrease indicates, invariably, a change of whatever caused it. The more tense and red the swollen lids are, the worse, as a rule, is the prognosis.

(*d.*) *Discharge* from the inflamed conjunctiva, if purulent, is mostly contagious. It is a mixture of decomposed intercellular substance, with different kinds of cells, as epithelial cells (which may be young or old, fully formed, or incompletely developed), mucus cells (with turbid contents and unusually small nuclei), pus cells, incompletely developed nuclei, fatty degenerated pus cells and nuclei. In commencing catarrhal ophthalmia, we find in the discharge fully and ill developed epithelial cells with one, rarely with two, nuclei, and mucus cells; and during the acute stage mucus and pus cells, and ill developed epithelial cells. In purulent ophthalmia we have mucus and pus cells, or merely pus cells. In severe purulent ophthalmia (pyorrhœa) we meet with few well formed pus cells, and with large numbers of ill shaped nuclei, which rapidly undergo fatty changes.

The consistence of the eliminated intercellular substance determines, in a great measure, the consistence of the discharge.

The discharge is viscid and transparent in chronic catarrhal ophthalmia. In the acute form it is viscid, transparent, and streaked with grey at the commencement, and is opaque and streaked with yellowish grey when the inflammation has reached its height. The more acute and severe the ophthalmia, the more abundant and thinner and the less viscid is the discharge. Its viscidity, i. e. the consistence of the intercellular substance, in which are suspended the different cell forms, prevents it from mixing with the tears. In high degrees of ophthalmia it becomes greenish, or yellow and opaque, and fluid, and mixes with the tears.

From microscopic examination it appears that, in purulent inflammation of the conjunctiva, the cells of the deeper layers of the epithelium, and the adjoining connective tissue corpuscles, become swollen. The former contain more fluid and granules. Their nuclei become larger, subdivide, and thus increase in number. Imperfectly formed epithelial cells, mucus cells, and finally pus cells, are thus developed. The cell walls of the connective tissue corpuscles become irregularly enlarged through increase of contents, nuclei, &c. The enlarged corpuscles anastomose with adjoining ones, and form a network, which encloses altered corpuscles (proliferous connective tissue corpuscles).

The substance occupying the space round the meshes of this network (the intercellular substance) undergoes a series of changes, both in consistency and transparency. These changes are most active close to the surface of the conjunctiva. The more quickly the nuclei in the connective

tissue corpuscles increase and their cells enlarge, the more rapidly do these nuclei reach the surface where they are eliminated as mucus and pus cells and granules. Epithelial cells are no longer formed if this change (i. e. the inflammation) reaches a great intensity.

(*e.*) *Intolerance of light* (Photophobia) and *spasmodic closure of the eyelids* are generally met with if, in the course of ophthalmia, the cornea, especially its surface, becomes implicated. Pus or mucus upon the cornea, or a vascular uneven surface, such as occurs during granular ophthalmia, or small ulcerations brought on by purulent ophthalmia, may give rise to these symptoms. Their severity and duration are no measure of the severity of the ophthalmia. Most intense and prolonged photophobia may exist with slight morbid changes of the cornea. The desire to exclude light induces the spasmodic closure of the eyelids.

The application of Tincture of Iodine to the skin of the eyelids twice a week (taking care that none of it runs "into the eye") frequently succeeds in removing the photophobia, and with it the spasmodic closure of the lids; but no treatment equals the insertion of a seton into the skin of the corresponding temple. By this means, within a week or a fortnight, a photophobia may be arrested which has resisted tonic and all other medical treatment for months.

(*f.*) *Profuse flow of tears* (Lachrymation, watering of the eye), as a rule, indicates implication of the cornea. When forcibly opening the eyelids, a gush of hot tears frequently escapes from the outer and upper portion of the fornix, where most of the ducts of the lachrymal gland open upon the conjunctiva.

A small superficial ulcer or a minute portion of inflamed cornea may give rise to lachrymation. Pustular corneitis is its most common cause. It generally occurs at the commencement of the different forms of purulent ophthalmia; and indicates an implication of the cornea, if it appears in the latter stages.

The treatment of catarrhal ophthalmia should be adopted if the slightest trace of yellow or mucous discharge is mixed with the tears. If eczema appears the crusts must carefully be removed from the eczematous spots with warm water. The "sore places" should then be washed with Lotio Aluminis, well dried, and the Unguentum Hydrargyri Nitratis Mitius applied. This must be repeated twice daily. The pure Liquor Potassæ is applied if the above treatment does not succeed.

(*g.*) *Pain*, if severe, in the purulent forms of ophthalmia, is a sign of implication (ulceration, suppuration) of the cornea. It is felt in the eye, over the eyebrows, and at the back part of the head, on the side corresponding to the "inflamed eye."

If in the course of purulent or of diphtheritic ophthalmia the pain

appears suddenly, continues for six or twelve hours, and then subsides more or less, a perforation of the cornea has happened.

An itching, pricking sensation accompanies the slighter forms of purulent ophthalmia. Pain without discharge of pus may be caused by changes in the cornea, or more frequently in the ciliary region.

Though we may not be able to inspect the cornea, we rarely fail to arrest the pain, during the acute stage of purulent ophthalmia, by the local application of ice ; and in other forms of ophthalmia or of corneal affections, where there is only watery discharge, by the frequent use of Atropia, and by the application of one or several leeches to the corresponding temple.

(*h.*) *Flashes of light, a mist, "Rainbow colours."*—Patients suffering from purulent ophthalmia occasionally complain of flashes of light darting across the eyes when in the dark. This is probably connected with congestion of the optic nerve.

The appearance of a mist, or of rainbow colours round the candle, or of rays shooting out from it, are probably caused by changes in the epithelial surface of the cornea.

When attending patients with ophthalmia, we must recollect—

(1.) That one form of ophthalmia may merge into another, e. g. gonorrhœal may commence like catarrhal ophthalmia, and granular may assume the characters of diphtheritic ophthalmia.

(2.) That at all stages, implication of the cornea, changes in the eyelids, &c., can call forth an additional series of symptoms which may be mistaken for those belonging to the ophthalmia.

(3.) That the purulent discharge is the symptom which most requires treatment, whatever may be the condition of other parts of the eye.

CAUSTIC AND ASTRINGENT REMEDIES.

These remedies are used in the treatment of all changes of the eye which are accompanied by purulent discharge from the conjunctiva.

They cause temporary irritation (with more or less destruction of the surface with which they come into contact) and a "serous secretion," which relieves the blood-vessels. Their action is increased by the subsequent application of cold.

The effect produced depends upon the kind of caustic, and upon the mode of application, e. g. if nitrate of silver, solid, or in solution, is lightly passed over the conjunctiva, and then washed away with salt water, less effect is produced than if it is allowed to remain in prolonged contact.

The pain caused by the application of the caustic is less if the lids are

thoroughly everted, and the conjunctiva well washed with water after the application.

The "caustics" generally used are—Nitrate of silver, sulphate of copper, sulphate of zinc, acetate of lead, and alum.

Solid nitrate of silver, or concentrated solutions, should be applied by the surgeon himself. When prescribing a lotion containing nitrate of silver, we must remember that if used for a long time it somewhat blackens the conjunctiva and sclerotic. This change of colour is first observed at the fornix. To remove it the hypophosphite of soda (gr. xx. ad aquæ destill. ℥i) applied twice daily by means of an "eye-glass," to insure a prolonged contact with the conjunctiva, is recommended.

Lotio Aluminis.—℞ Aluminis ʒ ss
Spirit. Vini rectif. ℥ ss
Aquæ Rosæ ad ℥viii. Misce. For catarrhal and other mild forms of purulent ophthalmia.

Lotio Aluminis.—℞ Aluminis gr. viii.
Aquæ destillatæ ℥i. Misce. For severe purulent and gonorrhœal ophthalmia.

Guttæ Argenti Nitratis.—℞ Argenti nitratis gr. ss
Aquæ destillatæ ℥ ss Liqua

Guttæ Cupri Sulphatis.—℞ Cupri Sulphatis gr. ii.
Aquæ destillatæ ℥i. Liqua

"Green Stone" (Lapis Divinus).—℞ Cupri Sulphatis
Nitri puri
Aluminis aa ℥i
Camphoræ rasæ ℥ ss

These ingredients to be moulded into sticks, and used for "touching" the conjunctiva when granular.

Guttæ Zinci Sulphatis.—℞ Zinci Sulphatis gr. ii.
Aquæ destillatæ ℥i. Liqua.

Glycerine Ointment.—This is made by mixing one part of amylum (starch) with five parts of pure glycerine; the latter having previously been heated to 102° Fahrenheit.

The ointment is soluble in water, always retains the same consistence, and mixes with the moisture upon the conjunctiva; it is therefore a useful vehicle for other remedies; e. g. for sulphate of copper, acetate of lead, nitrate of silver, red precipitate, &c., &c. Two grains of either of these ingredients, with one drachm of the glycerine ointment, are "equal in

strength" to four grains of the same ingredients when mixed with one drachm of fat.

PUSTULAR OPHTHALMIA.

(*Strumous Ophthalmia, Herpes conjunctivæ. Phlyctænular Ophthalmia.*)

The term Pustular Ophthalmia is derived from the small roundish circumscribed, generally grey and opaque, and more or less vascular, elevations or nodules, which characterize this ophthalmia.

The conjunctival and sub-conjunctival vessels, round the bases of the nodules or "pustules," are congested. The "pustules" vary in size, and are frequently situated in the conjunctiva, and frequently at or near the outer and inner margin of the cornea. They rarely occur on the palpebral conjunctiva. We may see them in their different stages, if several are present. They are looked upon as exudations among sub-conjunctival blood-vessels. They may change into ulcers before they disappear; or, if deep seated, form an abscess, accompanied by much swelling of the surrounding sclerotic. Sometimes we observe a group of these pustules at the margin of the cornea, standing close to each other, and causing a flat, circumscribed, grey-red swelling, which is sharply defined by the margin of the cornea, and surrounded by large blood-vessels.

Nodules or pustules, when situated at the end of a triangular-shaped bundle of conjunctival and sub-conjunctival blood-vessels, have been mistaken for pterygium.

The appearance of the pustules is preceded by a burning, stinging pain, by vascularity of the conjunctiva, with some mucous and watery discharge, and by intolerance of light if the cornea is implicated.

As to course and duration, we find, as a rule, that the nodule appears two or three days after the commencement of the vascularity of the conjunctiva. The vascularity decreases about the seventh day, and the conjunctiva assumes a darker red hue. This often coincides with the appearance of pus on the apex of the nodule, i. e. with the formation of the pustule.

The ophthalmia may be protracted by the appearance of fresh nodules, pustules, or ulcerations. The discharge, whether watery or muco-purulent, varies during the course of the ophthalmia. (For treatment of Pustular Ophthalmia, see Treatment of Pustular Corneitis.)

SCROFULOUS OPHTHALMIA (Strumous Ophthalmia).

This term is applied to various inflammatory changes of the eye, especially when occurring in children. Great intolerance of light, spasmodic closure of the eyelids, profuse watering, very little or no mucous discharge, with slight vascularity, are considered its characteristic symptoms.

Herpetic vesicles, pustules, small ulcerations of the cornea, circum-

scribed or diffuse corneitis, iritis, &c., may give rise to the above symptoms. (For treatment, and for further particulars, see Pustular and other forms of Corneitis.)

SIMPLE OPHTHALMIA.

In every case of undue vascularity (hyperæmia) of the conjunctiva we should particularly examine the state of the eyelashes, of the tear-ducts, of the puncta, and of the surface of the conjunctiva, especially the fornix, and the portions along the inner edges of the palpebral margins.

Minute yellowish-white and opaque deposits of chalk beneath the conjunctiva, working their way towards the surface,—an eyelash turned in the wrong direction, or lodged in one of the canaliculi,—the smallest particle of a foreign substance on a part of the conjunctiva which touches the cornea, may become the cause either of simple ophthalmia, or of chronic catarrhal ophthalmia. Working with too strong, and especially with improperly arranged, light,—continuous stay in rooms with arsenical wall paper,—and most frequently, anomalies of refraction, are other common causes.

The term febrile ophthalmia is applied to the hyperæmia of the conjunctiva, which so commonly occurs at the outset of, or after, severe fever.

CATARRHAL OPHTHALMIA.

Syndesmitis catarrhalis, Catarrho-Rheumatic Ophthalmia (if the sclerotic seems unduly vascular).

Catarrhal Ophthalmia is an inflammation of the conjunctiva, accompanied by moderate muco-purulent discharge.

The conjunctiva becomes vascular, generally first at the inner canthus. In severe cases a uniform redness of the ocular and palpebral conjunctiva, obscuring its large vessels, is observed.

In slight cases the vascularity is confined to the palpebral conjunctiva, or to the semilunar fold and caruncle. Numerous small blood spots may appear, especially among the enlarged vessels of the ocular conjunctiva. The swelling of the conjunctiva rarely amounts to chemosis. In weak persons œdema of the eyelids is observed. There is no intolerance of light unless the surface of the cornea be disturbed.

The discharge from the conjunctiva at first is viscid and clear, with a few opaque flocculi. The flow of tears is rarely increased. The discharge gradually becomes turbid, grey, and at last yellow (purulent), consisting of mucus and pus cells in moderate quantity, suspended in viscid fluid.

This discharge does not mix with the tears. Its decrease indicates a decrease of the ophthalmia. It gradually assumes the characters of a

normal secretion; or it becomes transparent and viscid, as in chronic catarrhal ophthalmia.

Patients generally state, that the inflammation commenced with a "stiffness of the eyelids," and with a sensation as if "sand had got into the eye." Severe pain and intolerance of light are unusual complications. During sleep there is no secretion, or very little, from the conjunctiva, especially in patients suffering from chronic catarrhal ophthalmia. After sleep a sensation of "dryness of the eye" is complained of. Any discharge accumulating round the eyelashes causes them "to stick together." This symptom is quite characteristic: and an affirmative answer to the question whether the eyelids "stick," at once indicates the necessity of using astringent lotions, in whatever state the remainder of the eye may be.

Mucus mixed with air bubbles and spread over the surface of the cornea, or changes in the epithelium of the cornea, cause objects to appear misty; and give rise to the perception of a halo, with or without "rainbow colours," round the flame of a candle, or to dark dots and shreds moving about before the "sight," and changing in shape and position after winking.

Acute catarrhal ophthalmia, if left without treatment, frequently gets well by itself (in about six weeks), or it goes on to purulent ophthalmia, or it may become chronic, or change into granular ophthalmia. Under treatment it generally subsides in from two to six weeks. Much intolerance of light, with pain and flow of tears, indicate implication of the cornea, and sometimes of the iris.

Causes.—Atmospheric changes,—such as occur in crowded rooms, or along the water-side after sunset,—and the contact of secretion from other mucous membranes (the vagina, the lachrymal sac), are the most common causes. It may appear during erysipelas, eczema, or herpes of the face. Injuries (e. g. after extraction of cataract),—pustules of the cornea, or conjunctiva,—changes along the palpebral margin, as tinea, ectropion, or protrusion of the eyeball, are occasional causes.

The so-called *Exanthematic Ophthalmia* which sometimes appears during measles, small-pox, scarlatina, &c., may assume the character of catarrhal ophthalmia. This condition may occur in one eye only, or in one eye sooner than in the other.

Treatment.—The application of astringents or caustics to the conjunctiva rapidly arrests the ophthalmia. The pain caused by these should not continue longer than from ten to fifteen minutes. If the eyes are tender to the touch, with much ciliary redness and pain, frequent bathing with cold water and rest are prescribed in the case of strong persons; while weak patients, if there be œdema of the lids, have to use fomentations with warm water, or warm poppy-head lotion.

Astringent lotions (the cleanest and cheapest of which is Lotio Alu-

minis) are ordered at once, if there is little or no intolerance of light and pain.

Before using the lotion, the discharge should be washed away from the lids with warm water, or milk and water; after which the margins of the eyelids and the inner corner "of the eye" are wiped frequently with a piece of lint dipped into the lotion; the patient, while doing this, should open and close the lids, so as to allow some of the lotion to "get into the eye." This is repeated from three to ten times daily for about five minutes at a time, according to the quantity of the discharge. The same piece of lint for bathing the eyelids should not be used a second time. At bedtime some glycerine ointment is applied along the margins of the eyelids to prevent their "sticking." Touching the palpebral conjunctiva gently with the green stone every other day as long as the discharge is abundant, hastens the recovery.

CHRONIC CATARRHAL OPHTHALMIA.

In chronic catarrhal ophthalmia the undue vascularity of the conjunctiva is chiefly confined to the caruncle and semilunar fold and to the margins of the eyelids. The lids are "occasionally gummed up." A few yellow or grey and opaque crusts may be seen hanging about the eyelashes.

This ophthalmia occurs frequently in old people who suffer from a relaxed condition of the blood-vessels of the conjunctiva, or from anomalies in the position of the eyelids (entropion, eversion of the tear puncta, &c.), or from chalky deposit among the meibomian glands. In young persons it may occur with anomalies of refraction or accommodation.

Treatment.—A careful examination of the state of the retina, of the accommodation, refraction, and tension of the eyes, will assist us in the treatment of the ophthalmia. Malposition of the lids, everted tear puncta, and discharge from the lachrymal sac should be attended to.

The use of Lotio Aluminis (gr. iv. ad aquæ ℥i.), twice daily, to wash the eyelids with; or the application of Guttæ Zinci Sulphatis—(Zinci Sulphatis gr. j. ad aquæ ʒi.), one or two drops to be placed upon the inner aspect of the lower lid of the "inflamed eye,"—often remove the ophthalmia. Some of the Unguentum Hydrargyri Nitratis Mitius should be smeared along the margins of the eyelids at bedtime if they are reddened. The treatment is discontinued as soon as the eyelids are no longer found glued together after sleep.

PURULENT OPHTHALMIA.

From the nature of the discharge during the acute stage, purulent ophthalmia is called by some *Suppurative Ophthalmia*, or *Conjunctivitis Puromucosa*, or *Ophthalmo-blenorrhœa.* From its occurrence in the army,

it has been termed, together with granular ophthalmia, *Ophthalmia Bellica, or Military, or Egyptian Ophthalmia.*

This ophthalmia receives the name of *Gonorrhœal Ophthalmia* when it occurs after contact of gonorrhœal pus with the conjunctiva. When it appears in new-born children the term *Ophthalmia Neonatorum*, or simply *Purulent Ophthalmia,* is used.

Pyorrhœa signifies a high degree of purulent ophthalmia, in which the purulent discharge mixes readily with the tears. In the less severe forms the pus and mucus mixed together float among the tears.

We shall distinguish between *Purulent Ophthalmia in infants* and *Purulent Ophthalmia in adults.*

On account of the rapid progress of the malady patients generally present themselves when a high degree of inflammation has been already reached. The symptoms at the commencement resemble those of common catarrhal ophthalmia, but in from six to twelve hours they may have changed into those of severe purulent ophthalmia. After thirty-six hours profuse purulent discharge, swelling and redness of the eyelids, and inability to open them, chemosis and haziness of the cornea may be present.

The purulent discharge escaping from between the eyelids, and the changes in the eyelids and in the conjunctiva, are the most conspicuous symptoms.

The less red and swollen the eyelids are the less severe is the ophthalmia, however abundant the purulent discharge may be. The less the lids are altered during the acute stage the better is the prognosis. Their state at this stage is a reliable guide as to the safety of the cornea and the general prognosis of the case.

The swelling of the eyelids is as a rule considerable, and frequently it becomes impossible for the patient or the surgeon to open them. The redness in severe cases extends from their edges to beyond the margin of the orbit; the upper lid overlaps the lower; or one or both are everted, and the swollen red, granular, pus-secreting tarsal conjunctiva is exposed. The ectropion is caused by the contraction of the orbicularis muscle, together with the swelling of the ocular and tarsal conjunctiva pushing the margins of the lids away from the eyeball. The tarsi become softened, swollen, and enlarged.

The more severe the purulent ophthalmia the more vascular and chemosed is the conjunctiva. The swelling of the papillæ of the conjunctiva, and the enlargement of its vessels, give to its surface a more or less granular appearance. The blood in the conjunctival vessels is not coagulated, but its circulation is retarded. The ocular conjunctiva frequently

overlaps the cornea, or completely hides it from view, during the acute stage. It may even project through the palpebral aperture.

The purulent discharge escapes from between the eyelids in large drops; it varies in colour; the more abundant the pus corpuscles the more yellow it appears. It becomes more like mucus and clearer as the pus diminishes. It continues abundant for some time after the other symptoms of the acute stage have passed.

Great danger to the eye arises from participation of the cornea in the inflammation. This is more likely to happen the more severe the purulent ophthalmia, and especially the more severe the chemosis. Purulent infiltration and ulceration of the cornea frequently occur. At first a circumscribed portion of the epithelium becomes opaque. This being thrown off, a small ulcer appears, which spreads rapidly in depth and along the margin of the cornea. It thus acquires a crescentic shape; its margin next the sclerotic is sharp, and its base and margins are infiltrated with pus. Sometimes there is little, or no purulent infiltration, the loss of substance in the margin of the transparent cornea alone marking the extent of the ulcer. The cornea, though not opaque, may be thrown off.

The pus which accumulates at the margin of the cornea beneath the chemotic conjunctiva is supposed to be the cause of the corneal changes.

The part of the cornea which has become semi-opaque or yellowish and opaque sloughs in part, or *in toto;* or it ulcerates and becomes perforated. Sometimes the crystalline lens escapes, especially if a large portion of cornea is destroyed rapidly. More frequently a prolapse of the iris occurs through the opening. The prolapse within a few days becomes swollen and covered with yellow lymph, then vascular, and finally is covered by opaque fibrous tissue.

If the entire cornea has been destroyed, we observe a few days later yellow lymph along the margin of the pupil, and subsequently upon the surface of the iris. The opaque cicatrices ("prolapsed portions of the iris covered with organized lymph"), following the perforation, often become staphylomatous.

The eye, through the escape of the crystalline lens and vitreous substance, may be greatly reduced in size, and shrink.

Secondary changes in the cornea, pustules, chronic ulcerations, or vascular corneitis, appear in some persons during the later stages of the ophthalmia.

The course of purulent ophthalmia is rapid. In from three to eight days it reaches its height, but its liability to pass on into pyorrhœa, or into diphtheritic, or granular, or chronic catarrhal ophthalmia, or to change from one of these forms into another, lengthens its duration.

As soon as the patient is able to open the eyelids spontaneously, we

know that the ophthalmia is decreasing. The redness, swelling, and tension of the lids and the chemosis become less, while the suppuration continues comparatively abundant for some time.

An increase of intolerance of light, of flow of tears, and of pain are at this period caused by changes in the cornea,—pustules, ulcerations, cicatrices, &c.

We consider the ophthalmia at an end as soon as the conjunctiva has resumed its transparency, and the lids are no longer "gummed up."

Causes.—The most common cause is contact of pus from another case of the disease, or of gonorrhœal pus, or (in infants) of discharge from the vagina.

Purulent ophthalmia may appear at any stage of diphtheritic ophthalmia, or it may increase to pyorrhœa.

Purulent ophthalmia produced by the same cause is more severe in adults than in children. It may occur in one eye only, but it is readily communicated to the fellow eye, unless the latter be protected against the contact of pus.

The Treatment is essentially local. Its chief object is to arrest the purulent discharge, and to protect the cornea.

The less considerable the chemosis the less danger is there of the cornea becoming implicated.

The sooner loss of transparency or ulceration (especially the crescentic ulcer) occurs, the worse is the prognosis.

We can hold out less hope of recovery of useful sight if the cornea is implicated before the ophthalmia has passed its height, or if the chemosis is already severe on the second day from the commencement.

The eye not affected should be kept bound up as long as there is the least purulent discharge from the inflamed eye. The bandage should be removed from time to time, and the skin of the eyelids washed with warm water, and some spermaceti ointment should be applied to it to prevent eczema.

The patient's friends must be warned against the contagious nature of the discharge.

Some recommend examination of the cornea in every case. If necessary chloroform is given in order to avoid pressure or straining. Though the examination cannot alter the treatment, it may enable us to speak more positively as regards recovery of vision.

Rapid ulceration, or loss of transparency, and sloughing of part, or of the entire cornea, are the usual causes of loss, or of impairment, of vision. The sooner the purulent discharge is stopped, or the sooner the surface of the cornea becomes vascular, the sooner is the danger of such a result removed.

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If gonorrhœal pus is known to have come into contact with the conjunctiva, it is safest to touch the entire palpebral conjunctiva with solid nitrate of silver. No fear need be entertained if no purulent discharge appears within from two to four days. The same treatment is adopted at any stage of the ophthalmia, however great may be the swelling of the lids, or of the conjunctiva. Chloroform should be given to avoid straining. During the administration the eye must be bound up to avoid the risk of perforation in case the patient should strain, &c. The lids are then everted, and the conjunctiva is cleansed from pus with warm water and wiped with dry lint. Deep incisions, so as to obtain abundant escape of blood, are made through the swollen conjunctiva. The incisions should radiate from the periphery of the cornea, and from the margins of the lids. After this, the bleeding having somewhat ceased, the palpebral conjunctiva, especially the fornix, is touched with the solid nitrate of silver. The surface of the conjunctiva becomes grey, white, and opaque, and covered with flakes of similar colour. Warm water is again used to wash away the free particles of nitrate of silver. Ulcerations or opacities of the cornea are also touched lightly.

The lids are then replaced into their former position, the patient put to bed, and a bladder or bag of ice placed upon the lids, to keep them as cool as possible. The lids every quarter of an hour are gently drawn apart, and some alum lotion out of a small bottle is poured upon the exposed conjunctiva, to wash away any discharge that may have accumulated.

If the cornea is in part or entirely opaque, and the chemosis severe, an incision is made through the outer canthus (through skin and orbicularis muscle), so as to relax the eyelids. This removes some of the pressure on the cornea and induces a free escape of blood.

The white and opaque slough caused by the nitrate of silver is sometimes thrown off in two or three hours, and purulent discharge reappears. Cauterization may have to be repeated the same day if the purulent discharge returns in abundance, unless the surface of the cornea has become vascular. In the latter case no fresh application is required, however severe the other symptoms may be. Ice or lint dipped in cold water, and the use of the alum lotion every quarter of an hour during the day and frequently at night, are continued as long as there is increase of purulent discharge, and the patient is not able to open the lids spontaneously.

The incisions, and the application of solid nitrate of silver, must be repeated the following day, and perhaps the day after, if the cornea is ulcerating or nebulous, and not covered with blood-vessels, and if the chemosis and swelling of the lids remain the same.

If the chemosis and the swelling of the lids are moderate the application of ice, and the use of the alum lotion, are sufficient. The alum lotion should be used every hour, and lint dipped in ice-cold water should be applied to the eyelids every quarter of an hour.

The use of the alum lotion every two hours, and bathing the eyes with fresh water three times daily, are ordered if the purulent discharge is moderate, and if the eyelids open spontaneously, whatever be the state of the cornea, &c. The use of the alum lotion may have to be continued for six or eight weeks.

Some Unguentum hydrargyri nitratis mitius spread along the margins of the lids at bedtime prevents their becoming "gummed up" during the night.

The occurrence of perforation of the cornea is generally indicated by a sudden severe pain, which continues for some time. The cautious but frequent use of the alum lotion, and gentle pressure upon the lids by means of a bandage, are requisite if this accident threatens. The same treatment is continued if perforation has occurred. Perforation generally happens at the spot which has first become opaque. Prolapse of the iris and staphyloma often follow. The eye still retains perception of light if the crystalline lens alone has escaped. It generally shrinks, more or less, if vitreous substance has been lost. In either case an artificial eye may be worn.

Some recommend paracentesis of the cornea, if the latter be ulcerating, or threatening to become perforated.

Pain, irritation, and undue vascularity of the conjunctiva may be kept up by a staphyloma after the purulent discharge has nearly ceased.

General symptoms, as fever, loss of appetite, &c., may require general medical treatment.

PURULENT OPHTHALMIA IN INFANTS.

The ophthalmia generally appears on the third day after birth, with symptoms similar to those in grown persons. In mild cases the eyelids open freely and appear normal, though the purulent discharge be abundant. In severe cases the lids are swollen and red, the conjunctiva chemotic, and unless a speculum be used to keep the lids open, no view of the cornea can be obtained.

The attempt to see the cornea (unless chloroform be given) may lead to perforation, with escape of the crystalline lens, vitreous, &c., and loss of the eye. A view of the cornea, even if obtained, cannot affect the treatment of the case, but may enable us to express a more favourable prognosis if the cornea should be healthy.

Our prognosis, if the swelling of the lids and conjunctiva prohibits a view of the cornea, or if the latter appears opaque or has become perforated, must be guarded. Children may recover useful vision though the entire cornea, except perhaps the posterior elastic lamina, may have been destroyed; or though a large abscess, or an opacity occupying three-fourths of the surface of the cornea, or a large prolapse of the iris, may have been present. An opacity occupying even the entire cornea, its curvature being otherwise normal, may disappear in about two years without treatment.

The prognosis is favourable, however abundant the purulent discharge, if the cornea is clear or only a small portion nebulous, provided the necessary treatment be carried out.

Vaginal discharge coming in contact with the conjunctiva of the infant is the usual cause of the ophthalmia.

Treatment.—The arrest of the purulent discharge is the chief object of treatment. Information should be given to the mother as to the condition of the eye, the cause of the "inflammation," and the chances as regards the recovery of vision, &c.

The eye not inflamed should be kept bound up, and treated as directed above.

The purulent discharge should be washed away with alum lotion. To do this properly several persons are required.

The child's head, well steadied, is held inclined towards the side of the inflamed eye, to facilitate the running of the lotion over the conjunctiva. The eyelids are "opened" gently, and without pressure upon the eyeball, and to a sufficient extent to permit a view of the conjunctiva. Alum lotion is then poured out of a small bottle into the "inner corner of the eye," to wash away the purulent discharge.

In severe cases, e. g. where the swelling of the lids prevents our obtaining a view of the cornea, the alum lotion should be used every five or ten minutes during the day, and every hour at night, for from three to five days, or until a view of the cornea can be obtained easily. To ensure the proper application of the lotion, we should first do it ourselves, and then see it done by the attendants of the child.

A few drops of a solution of nitrate of silver (Argenti nitratis gr. x. ad aquæ ℥i.) are applied by the medical attendant to the conjunctiva of the eyeball twice daily as long as the chemosis is severe.

The drops are discontinued, and alum lotion applied every two hours during the day, and every fourth hour at night, as soon as the child opens the lids spontaneously, whatever be the state of the cornea, or the quantity of the discharge. It suffices to use the alum lotion three times daily, and to clean the eyelids frequently with fresh water as soon as the redness of the lids has disappeared.

A case of moderately severe purulent ophthalmia recovers in from six to eight weeks. The use of the alum lotion every two hours for about three weeks suffices if the purulent ophthalmia is mild, i. e. if the cornea is clear, and the lids open spontaneously.

The "sticking together" of the lids can be avoided by applying glycerine, or spermaceti ointment, along the margins of the lids at bedtime.

(See treatment of *Opacities of the Cornea.*)

If a corneal opacity, or a prolapse of the iris, becomes staphylomatous, an early iridectomy must be performed: or if the staphyloma occupies the

greater part of the cornea, abscission of the staphyloma, with removal of the crystalline lens, may be necessary.

Occasionally we meet with children whose lids are red, swollen, and spasmodically closed, with comparatively little purulent, and more watery discharge: the skin of the lids and face is covered with crusts and eczematous patches; and the lips are swollen, especially the upper one. In these cases, besides the local treatment to arrest the purulent discharge, we order the skin of the face to be washed with alum lotion, and the Unguentum hydrargyri nitratis mitius to be applied to the eczematous spots after removal of the crusts. Internally the Liquor Potassæ Arsenitis ♏ii. to ♏v.) is given twice daily.

DIPHTHERITIC OPHTHALMIA.

This ophthalmia has been observed as a complication of croup, pneumonia, puerperal fever, diphtheritic changes in the mouth, nostrils, &c.

Ophthalmia following injuries, or catarrhal or granular ophthalmia, when too severely treated with "caustics," may assume a diphtheritic character. The ophthalmia is particularly frequent in children about two or three years of age.

Cases occurring at the outset of an epidemic of diphtheria are more severe than those occurring towards the end. The eye first attacked, as a rule, suffers less than the other.

This ophthalmia is comparatively rare in its pure form. It is generally mixed with other forms, e. g. the fornix may present the symptoms of membranous, and the conjunctiva on the tarsus those of diphtheritic, ophthalmia, while the ocular conjunctiva is chemotic.

The discharge from the same eye, when placed upon the conjunctiva of a second person, may produce purulent ophthalmia, and in the case of a third person diphtheritic ophthalmia.

The first signs of the ophthalmia appear in from eight to twelve hours after inoculation. Within twenty-four hours from the commencement we may already find a fibrinous infiltration of a grey or yellow and opaque colour, with only slight vascularity of the conjunctiva. The infiltration reaches its height on the third day. It generally begins to disappear from the sixth to the eleventh day, though it may remain stationary for several weeks.

A mixed form of membranous and diphtheritic ophthalmia exists, if thick, firm, grey, or yellow and opaque membranes appear upon the surface of the conjunctiva.

The characteristic symptom is an infiltration of the entire thickness of portions, or of the whole, of the palpebral conjunctiva, with a substance resembling fibrin. This gives the infiltrated part a pale-yellowish or reddish-white and opaque appearance. The surface of the conjunctiva is generally smooth, and effusions occurring upon it cannot be peeled off. The

blood-vessels being strangulated by the infiltration, very little or no blood escapes on incision. The course of the few vessels which may be visible cannot be traced; they appear and disappear abruptly in the infiltration.

The ocular conjunctiva at the commencement becomes yellow, anæmic, stiff, and chemotic; with small blood spots and a few large veins. The discharge consists at first of a dirty greyish translucent fluid, mixed with some blood and tears; at a later period numerous yellow shreds appear, which consist of fat, imperfect nuclei, pus cells, necrosed tissue, and fibrinous coagula, indicating a decomposition and elimination of the conjunctival infiltration. The discharge finally becomes purulent. The greatest quantity is furnished by the fornix.

The conjunctiva gradually becomes softer and more swollen. The infiltration disappears under great increase of the purulent discharge. Parts of the palpebral conjunctiva may appear red, while others still continue grey, white, and opaque; the red portions, being entirely deprived of epithelium, frequently bleed, and sometimes considerably, if the ophthalmia is severe, and if sloughing of large portions of conjunctiva occurs. The loose, red, projecting portions of conjunctiva resemble large red granulations situated upon a fixed base.

The ophthalmia in its later stages assumes the aspect of severe purulent ophthalmia. Relapses may occur, especially during the time when the conjunctiva becomes visible, i. e. when the red granulations appear. The cicatrices, which gradually form, are the more extensive the more considerable the fibrinous infiltration has been. In mild cases the conjunctiva shrinks but slightly; its surface assuming an anæmic, somewhat fibrous appearance. Symblepharon, varying in degree, sometimes with destruction of all the conjunctiva, is observed in severe cases. In others, the secreting parts of the conjunctiva seem destroyed, and we have what is termed Xerophthalmos.

Complications.—The cornea may become implicated a few hours after the commencement of the ophthalmia. During the sudden changes in the circulation in the conjunctiva, a grey or yellow and deep-seated opacity may appear in the cornea, with sloughing of superficial portions. Though but slightly opaque, it may within a few hours pass into suppuration, or an ulcer may occur. If early implicated, it is generally destroyed. Even small ulcerations are often followed by perforation, and by infiltration, suppuration, and sloughing.

Cases have occurred in which the suppuration extended into the vitreous chamber, causing ophthalmitis; others in which, through inadvertence on the part of the nurse or patient, the lens and vitreous substance have escaped through the perforated cornea. In these cases shrinking of the eyeball resulted.

The sooner the chemotic conjunctiva becomes vascular the better is the prognosis. A vascular cornea is less likely to be destroyed than a transparent one. Relapses of the ophthalmia rarely bring on corneal complications.

The prognosis is always unfavourable; the more so the older the patient, or the more severe the infiltration of the conjunctiva.

Treatment.—The patient should remain in bed as long as the eyelids cannot be opened spontaneously. Caustics applied during the stage of solid infiltration, previous to the appearance of pus, increase the stagnation in the blood-vessels, and make matters worse. Frequent (every five or ten minutes) washing of the eyelids with warm camomile tea, or with warm milk and water, is ordered if there is no sensation of increased heat.

In the latter case, ice or cold applications are indicated. The lint used must be changed as soon as it becomes warm, and the applications must be discontinued when the cold becomes unpleasant to the patient.

Deep incisions, until blood flows, made in a radiating direction from the cornea, and from the margins of the eyelids into the infiltrated conjunctiva, are likely to prevent sloughing, and to hasten the appearance of pus.

In strong children, and in adults, leeches are applied (from six to twelve) to the skin below the inner canthus. They may have to be repeated if the solid infiltration continues.

Astringent lotions are employed as soon as the infiltration changes its character, i. e. as soon as the discharge becomes purulent. Pieces of lint, moistened with a solution of nitrate of silver (gr. x. ad aquæ ℥i.), and tied over the closed eyelids, will be found of great use. They should be changed every six hours, the discharge being washed away each time with warm water.

If this application should be found inconvenient, the treatment of severe purulent ophthalmia must be adopted.

The sooner the cornea becomes implicated the worse is the prognosis. Ulcerations occurring in the beginning are much more likely to spread, perforate, &c., than those occurring at a later period of the disease. Infiltrations, or abscesses, or ulcerations of the cornea may appear as long as the ophthalmia has not passed its height. They are less dangerous if they occur during the purulent stage. Frequent tapping of the anterior chamber is recommended by some as soon as the cornea becomes at all affected.

Mercury is given, with a view of changing the character of the infiltration. To children we give an eighth, a quarter, or a third of a grain of calomel, twice daily, and order frictions with the mild mercurial ointment, half a scruple or a scruple to be rubbed into the axillæ every day.

No surgical treatment to remedy the injury done to the eyelids, the

conjunctiva, or the cornea, need be adopted until the ophthalmia has completely subsided.

MEMBRANOUS OPHTHALMIA.

This ophthalmia differs from the diphtheritic form inasmuch as the conjunctiva beneath the membranous effusion (on its surface) is soft, swollen, and vascular. In its other symptoms it resembles purulent ophthalmia. Cases occur in which all outward signs of inflammation, except the membranous exudation, are missing.

The exudation consists of grey, greyish white, or grey yellow and opaque fibrinous membranes, which appear upon the swollen vascular conjunctiva (ocular as well as palpebral, but especially upon the latter). They are attributed to changes in the intercellular substance of the superficial portions of the conjunctiva. These membranes may be torn off either in large pieces or in shreds. Beneath them we find the bleeding surface of the conjunctiva. The eyelids occasionally become glued to the eyeball in consequence of the membranes upon the ocular and palpebral conjunctiva being in contact.

The disease reaches its height in a few days. The membranes are then thrown off, and simple purulent ophthalmia follows.

The morbid changes of the cornea, and the complications arising from adhesions of the conjunctiva and of the eyelids, are similar to those observed in severe granular ophthalmia.

Treatment.—This ophthalmia is contagious, and localities where it has commenced should be avoided.

If one eye only is affected, the other should be kept bound up until all discharge has ceased.

The membranes are best pulled off with a pair of forceps. The bleeding conjunctiva should be touched lightly with the solid nitrate of silver, and the Lotio Aluminis should be frequently used (every ten or fifteen minutes).

The treatment of purulent ophthalmia is adopted as soon as the purulent discharge has set in.

GRANULAR OPHTHALMIA,

Granular Conjunctivitis, Granular lids, Granulations, Trachoma, Ophthalmia trachomatosa, or granulosa.

Patients suffering from granulations generally complain that they "cannot see," that "the sight is misty," that "a mist" and "rainbow colours appear round the flame of a candle;" and that after sleep or after exertion the eyes are "red and weak."

These symptoms are explained by the faulty secretion of the granular conjunctiva, and by changes on the surface of the cornea.

The margins of the lids and the semilunar fold and caruncle are reddened, and sometimes slightly swollen; the movements of the lids are impaired, and the upper one slightly droops if the granulations are numerous. In cases of longer standing we often find the surface of the cornea uneven, and vascular. This condition, as a rule, appears first at the upper margin of the cornea, over which blood-vessels are seen passing from the adjoining conjunctiva. On everting the eyelids we find the palpebral conjunctiva, and more particularly the fornix of the upper lid, more or less vascular and "granular." The term granular is taken from the resemblance of the surface of the conjunctiva to a granulating wound-surface.

The granulations, as a rule, appear first near the orifices of the tear ducts.

We distinguish several species of granulatinos.

Species 1.—*Little granules of the size and appearance of soaked sago grains, standing side by side, either in groups or single, and projecting from the nearly normal, or more or less vascular, conjunctiva.* They appear first in the fornix, and are seen in their purest form in cases which have never been treated. They gradually increase in number, and are looked upon as hypertrophied papillæ of the conjunctiva. They may exist for years without impairing vision. Slight attacks of "catarrhal ophthalmia," and a sensation of weakness after much reading, are the symptoms frequently complained of.

Spontaneously, or more commonly when treated, they assume the aspect of the next species.

Species 2.—*Vascular "red" granulations of different sizes.* They are largest in the fornix, with confluent bases resting upon the vascular hypertrophied conjunctiva, which in severe cases appears infiltrated with a semitransparent, gelatinous-looking substance. In slighter cases the sub-conjunctival tissue is not much implicated, and the granular surface of the conjunctiva can be thrown into folds.

The conjunctiva covering the tarsus may appear merely vascular, or covered with minute granulations, or in severe cases with similar ones to those in the fornix.

Species 3.—*Large pale-grey, grey-white, or yellowish-grey and opaque granulations.* Their shape, size, and subsequent changes are similar to those of the red ones. They rest upon the infiltrated conjunctiva and sub-conjunctival tissue, and reach their largest size in the fornix, and along the upper margin of the tarsus. A few large blood-vessels may be seen among them. They secrete less than the red ones.

The granules of species 1 consist of gelatinous, transparent, intercellular substance. They appear to be excrescences of that part of the conjunctiva which lies immediately beneath the epithelium. They are covered by

young proliferous epithelial cells, and by some connective tissue; and are surrounded by enlarged, elongated, small blood-vessels, which bear some relation to the arrangement and growth of the granules. The red granules differ from species 1 in exhibiting a greater proliferation of epithelial cells, a greater accumulation of the gelatinous intercellular substance, and a higher degree of vascularity. The increase of intercellular substance, together with the dilatation and increase of the conjunctival blood-vessels, and the hypertrophy of the connective tissue corpuscles, gives rise to swelling of the conjunctiva between the granulations.

Species 4.—*Small, easily bleeding, flabby granulations of equal size, which stand side by side and give the surface a somewhat rough villous appearance. The conjunctiva covering the tarsus is swollen, intensely red, and easily bleeding.* This condition is confined to the papillous portion of the tarsal conjunctiva, while the conjunctiva of the fornix, the semilunar fold, and the caruncle are swollen and highly vascular. Sometimes there is much muco-purulent discharge. These granulations generally occur in young persons, and in both eyes simultaneously; they probably are of syphilitic origin.

The use of the Lotio Aluminis three times daily, to remove the purulent discharge,—the frequent washing of the lids with warm water,—the application of some of the Unguent. hydrargyri nitratis mitius along the margins of the lids at bedtime,—and internally from $\frac{1}{20}$ to $\frac{1}{12}$ of a grain of the Bichloride of Mercury in half an ounce of water, twice daily,—should be tried.

Some leeches to the temple, or the Tincture of Iodine painted upon the skin of the eyelids, may be of service if there is intolerance of light.

The treatment of granulations of species 1, 2, and 3 is not applicable to this form.

Species 5.—*Large flabby, red, and rather hard and elastic granulations of varying size, resembling condylomata in shape, with hardly any, or no purulent discharge.* They occupy the palpebral conjunctiva, and frequently also the semilunar fold. In the fornix they may reach several lines in diameter. They often continue for years without impairing the transparency of the cornea. When very numerous they may prevent the eyelids from closing, and cause them to stand away from the eyeball, and sometimes even to become everted. They not unfrequently are confined to the conjunctiva of one eye only. The sub-conjunctival tissue is much hypertrophied.

This species is rare, and occurs by preference in young persons suffering from glandular swellings. By some it has been described as *Exophthalmia Fungosa.*

Neither inoculation, nor any local nor general medical treatment, is of much benefit. Excision of the granulations is the remedy frequently

adopted, though this also is unsatisfactory, inasmuch as the loss of the conjunctiva, and subsequent cicatrices, may lead to inversion of the eyelids, to excessive shortening of the conjunctiva, and to symblepharon. Such a result is especially likely to follow if much intervening conjunctiva be removed with the granulations, or if too many be excised at the same time.

We therefore at first with scissors cut away only the most troublesome granulations, and allow the conjunctiva to cicatrise before removing others. We spare the conjunctiva round the base of the granulations as much as possible. The frequent use of tepid water, or of warm Lotio Papaveris, to wash the eyelids, and a linseed meal poultice upon the closed lids during sleep, can be recommended.

The granulations of species 1, 2, and 3 are closely allied. Treatment and time alter their appearance. Species 4 and 5 are wholly different from each other, and from the other species.

The duration and course of species 1, 2, and 3 vary. If not disturbed by treatment, we may find the sago-grain granulations remain for one or two years without disturbing vision, and only occasionally giving rise to redness of "the eyes." The attacks of "ophthalmia" gradually become more numerous and severe, and the granulations change colour, becoming red (vascular). Photophobia, profuse watery and mucous discharge, redness of the eyelids, and slight chemosis of the ocular conjunctiva, may appear during an attack. The surface of the cornea (and as a rule its upper portion first) becomes vascular (? from friction of the granulations against the cornea). The vessels encroach from the adjoining conjunctiva. The red granulations after each attack of ophthalmia appear more numerous. During the intervals the eyes feel "weak," and redden up easily.

The transparent, the red, and the grey and opaque granulations may be found with cicatrices in the same conjunctiva. They become smaller, flatter, and finally disappear, either spontaneously, or under treatment, probably by repeated and rapid elimination of the conjunctival epithelium, and by absorption of the intercellular substance. They often remain stationary for years, as red, flat, slightly secreting granulations.

The granulations, whatever be their mode of disappearing, lead to destruction of a certain amount of conjunctiva. Deep cicatrices remain, which occupy its entire thickness, and give to its surface an anæmic, whitish, or tendinous aspect.

The cicatrices appear as white or grey opaque bands and striæ, or as tendinous white and opaque patches of varying size. In the fornix we find anæmic folds of conjunctiva, or opaque fibrous bands, stretching across the fornix from the ocular to the palpebral conjunctiva. The conjunctiva becomes shortened through shrinking of the cicatrised portions. This by some is termed "*Posterior Symblepharon.*"

The ocular conjunctiva at first is not at all, or but slightly, vascular.

Its vascularity readily appears on irritation, and gradually increases. In rare cases the conjunctiva becomes granular near the canthi. During an acute attack of ophthalmia it may become chemotic. It gradually loses its elasticity, and often atrophies. The caruncle and semilunar fold become smaller, and sometimes shrink away completely.

The implication of the cornea necessarily causes impairment of vision, and being accompanied by more or less intolerance of light, and pain, is in poor persons frequently the first symptom which induces them to seek advice.

The granulations may exist for years before the cornea suffers: but in some cases this happens soon after their first appearance. Improper treatment, or granulations in the tarsal conjunctiva of the upper lid, rapidly implicate the cornea. The changes of the cornea are more troublesome during an attack of ophthalmia. The attack having passed, the granulations remain; and the cornea may resume sufficient transparency to admit of the patient following his occupation, and thus he may believe the "disease" to be cured. The changes of the cornea may occur in both eyes simultaneously, though generally with a difference of degree. On finding the surface of the upper half of each cornea vascular, and the lower half transparent, or nearly so, we are hardly ever wrong in pronouncing the case, even without everting the upper lids, to be one of granular ophthalmia.

The frequent contact of the upper portion of the surface of the cornea with the granular conjunctiva seems to be the cause of this part of the cornea being affected first. At first the surface becomes uneven, as if portions of epithelium had been removed; or smooth roundish indentations are observed in it, as if one or several granulations had moulded themselves into the cornea. Finally, *Pannus* forms, i. e. the surface of the cornea becomes more or less covered with a network of blood-vessels which encroach upon it from the adjoining conjunctiva and sclerotic. The term *Pannus trachomatosus* is used by some to distinguish Pannus caused by granulations from that which is caused by other morbid changes, e. g. herpes of the cornea.

In slight degrees of Pannus we find (microscopically) a great increase in thickness of the layers of epithelial cells of the cornea, with blood-vessels and fusiform cells upon and beneath the anterior elastic lamina, which itself may appear intact. In higher degrees, portions of the anterior elastic lamina disappear, and connective tissue and blood-vessels are mixed up with the thick irregular layers of epithelium. The bulk of the cornea often remains transparent, though its surface may be covered with opaque tissue and blood-vessels.

The opacity, if such exists, rarely occupies the entire thickness of the cornea. It is situated beneath the anterior elastic lamina. It consists at first of capillaries: afterwards numerous closely-packed fusiform cells,

with very little intercellular substance, appear. The rapid increase of these cells leads to a disappearance of the intercellular substance. The more abundant the cells are the greater is the opacity. The cells of the cornea, adjoining the opaque part, are larger and more numerous than in health.

Ulcerations or purulent infiltration of the cornea, followed by perforation or dense opacities, frequently occur during acute attacks of granular ophthalmia.

The surface of the cornea in severe cases appears covered with a grey, or red, and opaque vascular, somewhat granular, substance, which is continuous with the swollen ocular conjunctiva, and which is termed *Pannus Grassus;* it may continue for years before it changes into loose opaque connective tissue.

The ulcerations, purulent infiltration, or the pannus, are often accompanied by softening of the adjoining cornea, and may be followed by anomalies of curvature.

The appearance of the eyelids varies. The upper ones slightly droop, and cover the upper part of the cornea. This gives to the patient a sleepy expression. The drooping is in part due to the increased weight of the eyelids, but chiefly to the fact that the patient thus feels more comfortable, and sees better. During acute attacks, especially if the cornea is implicated, the lids are red, swollen, and sometimes spasmodically closed. The tarsi gradually become soft and enlarged, and the eyelids temporarily too large. The lower eyelids sink away from the eye, and frequently are somewhat displaced by large granulations. At a later period the tarsi shrink, and change their shape; and trichiasis, entropion, ectropion, narrowing of the palpebral aperture, &c., follow. The roots of the eyelashes and the meibomian glands frequently become destroyed.

Small tumours, filled with a chalky or fatty substance, occur in the tarsus, as one of the results of obliteration of the gland ducts.

If the conjunctiva is extensively destroyed, all movement of the lids and eyeball may become arrested, the inner edge of the palpebral margin being fixed to the surface of the eyeball, not from adhesion of the one to the other, but from gradual shrinking of the rest of the ocular and palpebral conjunctiva.

This shrinking commences in the fornix, and thence advances towards the cornea and palpebral aperture.

The more or less profuse flow of tears may be the result of reflex irritation from the cornea, or may be connected with swelling of the lining membranes of the tear-ducts, or with granulations in the lachrymal sac. In the latter stages of granular ophthalmia we not unfrequently observe eversion of the tearpuncta, distension of the lachrymal sac by mucus or pus, and strictures or closure of some parts of the lachrymal passages.

The discharge during acute attacks of granular ophthalmia is profuse,

watery, and mixed with some mucus or pus; in some cases it is muco-purulent and abundant, as in catarrhal ophthalmia. During the chronic stage it varies; there may be none. The lids are slightly "gummed up" in the morning, and some mucus may hang about the eyelashes and canthi during the day.

In old cases, though the conjunctivæ be covered with granulations, there may be neither discharge of mucus nor tears.

Causes.—Any one of the different forms of purulent ophthalmia may be followed by hypertrophy of the papillæ of the conjunctiva, causing a granular appearance, which readily ceases under the use of some mild astringent lotion.

The granulations of species 1, 2, and 3 are probably always the result of the contact of some organic substance with the ocular conjunctiva. Among such, discharges from the vagina, or from a granular conjunctiva, are the most usual. The use of the same water, towels, &c., for washing, is a frequent cause of the ophthalmia spreading in schools, barracks, &c.

Treatment of the granulations of species 1, 2, and 3.—Severe chronic cases of granular ophthalmia undoubtedly get well spontaneously: or one "eye" may get well, and the other remain granular. In children numerous large granulations may disappear within a few months. A slight hyperæmia of the palpebral conjunctiva seems particularly to favour the development of granulations; while a diffuse considerable hyperæmia materially assists in their disappearance.

In most cases, unless properly treated, the granulations continue for years, and according to their number and situation, lead to the changes in the conjunctiva, cornea, &c., described above. The granulations are intimately connected with the conjunctiva. They cannot be removed without destroying some conjunctiva.

Granulations are generally treated with caustics. Those commonly used are the Sulphate of Copper ("blue stone"); a mixture of the latter with Alum, &c. ("the green stone," or Lapis divinus); the Nitrate of Silver; the crystallized Nitrate of Silver (one part) with Saltpetre (two parts) melted into sticks, and (for protection) covered with gauze and collodion; and the powdered Acetate of Lead (used in chronic granular ophthalmia). The latter, when sprinkled upon the conjunctiva, remains between the granulations, causes the surface of the conjunctiva to become more uniform, and contributes towards the shrinking of the granulations. The Guttæ Cupri Sulphatis (gr. ii. ad aquæ ℥i.) are frequently prescribed, also the Lotio Plumbi Acetatis (gr. x. ad aquæ ℥i.). The Unguentum Cupri Sulphatis made with Glycerine may be found of use.

During an acute attack of granular ophthalmia, especially if there is much purulent discharge, and if we do not wish to evert the lids, and touch the conjunctiva with the "green stone" (which, though comparatively pain-

ful, is the most speedy remedy), we order the margins of the lids to be washed every hour during the day with the Lotio Plumbi Acetatis, and with cold water, as long as the sensation of cold is pleasant. After from four to six days, whether the acute inflammation has subsided or not, we either touch the granulations with blue or green stone, or order the instillation of the Guttæ Cupri Sulphatis.

At the Hospital the following course is adopted in every case of granulations (species 1, 2, and 3). The patient is seated, and rests his head against the chest of the Surgeon, who stands behind. The upper lid is everted, and the conjunctiva wiped with a piece of dry lint. The granulations are then lightly touched with the green stone. Those in the fornix are touched first (by passing the green stone to and fro behind the upper margin of the everted tarsus), then those on the tarsal conjunctiva; and after replacing the upper lid, those on the fornix and conjunctiva of the lower lid. The worse eye should be attended to first.

The touching is repeated every day, or every second day, for two or three weeks, until the granulations have become smaller, and less numerous. Touching twice a week then suffices. Care should be taken to touch the granulations only, and not the conjunctiva between them, nor the cicatrices.

The Guttæ Cupri Sulphatis or the Lotio Plumbi Acetatis (a few drops of the former, or some of the latter to be poured upon the inner aspect of the lower lid twice daily) are prescribed if the patient can be seen only once a week. Frequent ablutions of the eyelids with warm or cold water, whichever the patient finds to suit him best, are ordered if we touch frequently with caustic.

If the upper half, or more, of the surface of the cornea is vascular, or if ulceration or purulent infiltration of the cornea exists, then instillation of a few drops of a solution of Atropia three times daily, and frequent washing of the eyelids with warm Lotio Papaveris, are ordered, and the granulations are daily touched slightly with the green stone. This is continued until the cornea assumes a smoother and more healthy appearance.

If the lids are much swollen and tense, and seem to press upon the cornea, an incision about half an inch in length is carried through the outer canthus. The wound is allowed to bleed freely, and prevented from closing for a week, by passing a probe into it.

From three months to two years may elapse before the granulations, if properly treated, have disappeared. Poor patients generally cease to attend as soon as "sight" becomes useful, instead of continuing to do so until the granulations are entirely cured.

The object of the application of the green stone and of other caustics is, not to destroy the granulations, but to excite such irritation in the conjunc-

tiva as is best adapted to promote the elimination of the material of which the granulations consist.

A linseed-meal poultice tied over the eyelids during sleep, and frequent fomentations of the lids with lint dipped in hot water (causing great hyperæmia of the conjunctiva), have been found to remove the granulations without any additional treatment.

In granular ophthalmia if the cornea is not at all, or only slightly, affected, and the patient is able to follow his employment, we touch with caustic once a fortnight, and prescribe lotions or drops (the Lotio Plumbi Acetatis, or the Guttæ Cupri Sulphatis). We must be careful to adapt the strength of these remedies to the sensibility of the conjunctiva, and recommend the patient to add water until the remedy, when applied to the conjunctiva, causes pain for from ten to fifteen minutes only.

Ointments or drops are applied by means of a camel's hair brush; the lower lid being drawn away from the eyeball, and the conjunctiva touched with the brush.

Towels, lint, sponges, &c., used by patients who suffer from granulations, must not be used by any one else. The hands must be washed after having touched eyes so affected.

The Authorities of schools, barracks, &c., should be informed of the contagious nature of the "ophthalmia." Those suffering from it, while under treatment, should be kept separate from others.

If during an acute attack of granular ophthalmia the lids become everted spontaneously, and when replaced do not readily keep in normal position, they may be left alone until the acute attack has subsided.

Complications arising from implication of the lachrymal passages should be attended to while the granulations are under treatment. Everted lachrymal puncta and canaliculi should be slit open, and purulent discharge from the lachrymal sac treated without delay.

Corneal opacities, if slight, disappear spontaneously when the granulations and cicatrices of the conjunctiva cease to irritate the cornea. Dense opacities become thinner, and occasionally disappear, during an attack of corneitis. (See treatment of corneal opacities.)

Syndectomy is performed if the surface of the cornea continues vascular, with the palpebral conjunctiva thickened and its blood-vessels varicose.

If the entire surface of the cornea or two-thirds of it are vascular, so as nearly or completely to hide the iris from view, the conjunctiva being granular, *Inoculation* is performed.

The inoculated patients need not be kept in the hospital if both eyes have been inoculated, but the attendants must be warned against the contagious nature of the discharge. The fellow-eye, if only one eye has been inoculated, is kept carefully closed until the purulent discharge has completely ceased.

To keep the not-inoculated eye securely closed, a layer of Canada Balsam, or Gum Mastic, is spread over the skin of the closed eyelid, and the adjoining side of the nose. Upon this wadding is placed sufficiently thick to become level with the bridge of the nose and the margins of the orbit; over this a light bandage is tied. Whenever the bandage becomes loose it is removed and a fresh one applied. The discharge of the inoculated eye must be carefully guarded against while changing the bandages.

The object of inoculation is to set up the purulent ophthalmia. During the ophthalmia the granulations become smaller and smaller, and the vascular covering of the cornea is thrown off in yellow and opaque shreds.

Mode of Inoculating.—A drop of pus from the conjunctiva of an infant suffering from purulent ophthalmia is placed upon the conjunctiva of the lower lid of the eye we wish to inoculate, and left there. The first signs of purulent ophthalmia appear after from twelve to thirty hours.

As treatment we merely recommend cleanliness, however severe the purulent ophthalmia may be. The discharge should be washed away with tepid water every hour if the pain is severe, and if moderate twice a day.

The acute stage of the ophthalmia lasts from one to four weeks, the subsequent chronic purulent discharge from two to eighteen months.

In all cases (about three hundred) treated in this manner, the granulations disappeared.

The difficulty (when inoculating an eye with nearly transparent cornea) is to produce that degree of purulent ophthalmia which destroys the granulations without damaging the cornea. Those not familiar with the treatment of gonorrhœal ophthalmia should confine inoculation to the cases in which the entire surface of the cornea, or two-thirds of it, are vascular and more or less opaque, and the iris barely visible. In such, inoculation is safest.

Many patients, who had mere perception of light before inoculation, now enjoy again useful and lasting sight.

The curative effect of the inoculation may be considered at an end as soon as the eyelids are no longer glued together after sleep.

After the granulations have disappeared some improvement of sight may still be obtained by surgical and optical means.

XEROSIS.

Xerosis signifies a peculiar alteration of the secreting power of the conjunctiva.

The conjunctiva assumes an opaque fibrous appearance; its surface becomes covered with dry epithelial scales, fat, and particles of chalk.

This form by some is termed Xerosis squamosa, to distinguish it from Xerosis glabra, in which the surface of the altered conjunctiva is moistened by tears.

Sometimes all the conjunctiva is destroyed except a narrow dry and opaque band which extends from the margin of the eyelids to the eyeball, and completely prevents the movements of the eye. Thickening and distortion of the tarsus and inversion of the eyelashes are usual complications.

The surface of the cornea, the curvature of which may be good, is dry, covered with crusts, epithelial scales and a semitransparent cuticle.

Xerosis occurs after long-continued or badly-treated ophthalmia, especially the diphtheritic or granular form. See Granular Ophthalmia.

Entropion, Ectropion, or Trichiasis, chemical injuries and burns, are other causes.

No curative treatment is known. Frequent bathing of the cornea with warm milk, or the application of glycerine, may be found beneficial.

CHAPTER V.

THE EXTERNAL MUSCLES OF THE EYEBALL.

ANATOMICAL AND GENERAL REMARKS.

The external muscles of the eyeball receive their blood from branches of the ophthalmic artery. The blood is carried off by veins which lead, some into the facial, others into the ophthalmic vein. The nutrition of the muscles increases with exercise, and rapidly adapts itself to changes in this respect.

The motor nerves supplying the muscles are the third, fourth, and sixth. These have been traced within the skull as far back as the Pons Varolii and the Medulla Oblongata. The nerves pass through the sphenoidal fissure into the orbit; and as they do so they are nearer together than elsewhere.

The third nerve supplies the levator palpebræ, the internal rectus, the superior and inferior recti, and the inferior oblique (and the iris), and, according to some anatomists, also the external rectus. The fourth nerve supplies the superior oblique. The sixth nerve supplies the external rectus.

The tendons of the muscles penetrate the sclerotic, and break up in its middle layers.

The Internal Rectus muscle is firmly attached to the periosteum near the inner margin of the optic foramen, and loosely to the subconjunctival fascia and tissue. It is inserted into the sclerotic about $2\frac{1}{2}'''$ from the margin of the cornea. It is the strongest and largest of the recti muscles, its greatest width being about $4'''$.

Function.—It draws the cornea horizontally inwards towards the inner canthus without altering the inclination of its vertical meridian.

The Inferior Rectus muscle arises from the periosteum near the lower margin of the optic foramen, and is inserted into the sclerotic about $3'''$ from the lower margin of the cornea. The middle of its sclerotic insertion lies about $\frac{1}{2}'''$ to the inner side of the vertical meridian of the cornea.

Function.—If acting alone it draws the cornea downwards, and slightly inwards, inclining its vertical meridian outwards. Its action is opposed by the "superior oblique," which draws the cornea downwards and outwards, inclining its vertical meridian inwards. Both muscles acting together draw the cornea straight (vertically) downwards.

The Superior Rectus muscle arises from the periosteum near the upper margin of the optic foramen, and passes forwards and slightly outwards over the sclerotic, into which it is inserted at about $3'''$ from the upper margin of the cornea. The line of insertion is not parallel with the margin of the cornea, but somewhat slanting, so that the inner margin of the tendon is about $1'''$ nearer the margin of the cornea than the outer.

Function.—When acting alone this muscle moves the cornea upwards and slightly inwards, inclining its vertical meridian inwards. In this it is counteracted by the "inferior oblique," which turns the cornea slightly upwards and outwards. The combined action of both muscles causes the cornea to be drawn straight (vertically) upwards, the vertical meridian of the cornea remaining vertical.

The Inferior Oblique muscle arises from the periosteum within the orbit near the orbital edge of the superior maxillary bone, close to the outer side of the lachrymal sac. It passes backwards and outwards along the floor of the orbit, beneath the inferior rectus, to which it is loosely attached, and then following the curvature of the sclerotic, it becomes inserted into the latter exactly over the yellow spot, and opposite to the insertion of the "superior oblique." Its line of insertion, however, does not run parallel with that of the superior oblique. A needle thrust through the middle of its line of insertion and through the tunics into the eye passes through the centre of the yellow spot.

The branch of the third nerve which supplies this muscle also sends a branch (the motor root) to the ciliary ganglion.

Function.—This muscle rolls the cornea upwards and outwards, and inclines its vertical meridian outwards.

The Superior Oblique muscle ("the Trochlearis") arises from the periosteum near the inner margin of the optic foramen. It passes forwards towards the inner and upper margin of the orbit. Close to the latter, still within the orbit, is attached a fibro-cartilaginous ring—"the Trochlea"—through which a tendinous portion of the muscle glides. Thence the muscle takes a direction outwards and backwards, passes beneath the upper rectus, then becomes broader (about $2'''$ wide), and is inserted into the sclerotic about $3'''$ above the yellow spot. The nearest point of the optic nerve where it joins the sclerotic is about $4'''$ from the nearest point of the insertion of this muscle. It is supplied by the fourth nerve, and, according to some, receives also a branch of the third.

Function.—When acting alone this muscle rotates the cornea out-

wards and downwards, and inclines its vertical meridian inwards. If both oblique muscles (the superior and inferior) act forcibly together, they draw the cornea towards the outer canthus. They assist the recti muscles, and rotate the eyeball round an imaginary axis, the anterior pole of which is external to the anterior pole, and the posterior internal to the posterior pole of the eyeball.

The External Rectus muscle is a long narrow muscle which arises from the periosteum at the outer margin of the optic foramen, and is inserted into the sclerotic about $3\frac{1}{2}'''$ from the outer margin of the cornea. It is supplied by the sixth nerve.

Function.—This muscle draws the cornea straight (horizontally) outwards, and does not alter the inclination of its vertical meridian.

Having shortly stated the function of each muscle, it remains to show:—

(1.) What muscles come into play during the combined movements of both eyeballs.

(2.) The means by which the amount of contraction of the muscles during binocular vision may be ascertained.

(3.) The method of demonstrating the changes of position which especially the cornea and retina undergo during movements of one eye, or of both.

Some of the terms made use of in describing these movements refer to the positions of the eyes in relation to the head.

Looking up, or moving both eyes upwards, signifies that the visual lines are raised, the corneæ approaching the upper margins of the orbits. Fixing an object equidistant from both eyes, or converging the eyes towards an object, implies a convergence of both visual lines towards the median line, &c., &c.

The object of most movements of the eye is to direct the visual line to the point which we wish to see accurately.

In order to cause the images of objects to fall on the most sensitive parts of the retinæ, the eyeballs have to execute certain movements, which are preceded by a wish to turn the eyes in the necessary direction. If we wish e.g. to turn the eyes towards our right side, we have to imagine an object situated in that direction, and then to look towards it. When we wish to converge the eyes we look towards an object which we imagine situated about the median line of the body.

A continuous innervation of the muscles of both eyes is required to maintain the direction of both visual lines to one point of an object. A person who uses one eye only for vision may direct the visual line of the other eye properly for certain positions. The eye, the vision of which is impaired, deviates if the object is brought into a position in

which an unusual amount of muscular power is required for distinct vision, e. g. when the object is held near the eye.

Each visual line, together with the different parts of the eyeball, moves round an imaginary fixed point, termed the centre of motion, which point lies within the eye.

The angle which the visual line of one eye forms with that of the other, when the muscles of both eyes are at rest, is termed the muscular mesoropter. The visual lines are then inclined towards each other, and if prolonged would meet at a point situated at about 6′ from the eyes.

The angle formed by the visual lines when meeting at a point is termed the angle of convergence.

The nearer such point is to the eyes the greater is the angle, i. e. the inclination of the visual lines towards each other. During reading the angle is about eleven degrees (11°).

The axis of the cornea, if prolonged to the opposite point of the eyeball, is termed the axis of the eyeball, or the "visual axis." It does not coincide with the visual line. As stated under Strabismus, an eye may apparently squint inwards or outwards, and yet the visual lines may be directed properly. The visual line passes through the cornea near the inner (nasal) side of the axis of the cornea. This axis crosses the visual line at the nodal point (the crossing point of the rays within the eye) under an angle varying in the normal eye from 3° to 7°.

An imaginary plane laid through the visual lines and the point to which they are directed is termed the visual plane.

The movements of both Eyeballs may be subdivided into—

(1.) Associated movements. In these the visual lines remain parallel.

(2.) Accommodative movements. In these the visual lines are more or less inclined towards each other.

Some distinguish between a primary position of the eyes in which the visual lines are parallel and 45° below the horizontal, and secondary positions in which the eyes are rotated round a vertical, or a horizontal axis, or obliquely upwards or downwards.

Several muscles are at work in every movement to prevent, as some suppose, the individual muscles from becoming fatigued too soon. More muscular power is required when looking upwards or downwards than when looking outwards or inwards. The least fatiguing movement is the one in which both eyes are directed inwards and downwards; the most fatiguing is the one in which they are directed outwards and downwards. When looking at objects muscular power is consumed in overcoming the resistance offered by the muscles themselves. The action of the contracting muscle is opposed by the elasticity of its antagonist; and further resistance is offered by the structural elements of the contracting muscle itself.

Oblique or diagonal movements require the action of three muscles (of two recti and one oblique).

The vertical meridian of one cornea remains parallel with that of the other during oblique movements upwards, but is inclined towards the side towards which we look. For example, when looking outwards upwards and towards the left, the vertical meridian of the cornea of the left eye is inclined outwards, i. e. towards the left, while that of the cornea of the right eye, remaining parallel with it, is inclined inwards, i. e. also towards the left.

The vertical meridians also remain parallel, but inclined in a direction opposite to the one in which we look during oblique movements downwards. For example, when looking downwards outwards and to the left, the vertical meridians remain parallel, and are inclined towards the right, i. e. that of the left cornea is inclined inwards towards the median line, and that of the right cornea outwards and away from the median line.

The oblique movement upwards and inwards is carried out by the superior and internal recti and the inferior oblique. The cornea is drawn upwards and inwards and rotated inwards. Its vertical meridian is inclined inwards. The superior rectus contracting somewhat more than the others is regulated in its action by the inferior oblique, which during this movement offers most resistance.

The movement downwards and inwards is carried out by the inferior and internal recti and the superior oblique. The cornea is drawn downwards and inwards, and rotated outwards. Its vertical meridian is inclined outwards. The rectus inferior, which exercises most power, is limited in its action by the superior oblique.

The movement upwards and outwards is carried out by the superior and external recti and the inferior oblique. The cornea is drawn upwards and outwards, and rotated inwards. Its vertical meridian is inclined outwards. The inferior oblique not only counteracts the tendency of the superior rectus to incline the vertical meridian inwards, but even also inclines it outwards.

The movement downwards and outwards is carried out by the inferior and external recti and the superior oblique. The cornea is drawn downwards and outwards, and rotated inwards. Its vertical meridian is inclined inwards.

Vertical movements.—In these the eyeball is rotated round a horizontal axis, the vertical meridian of the cornea remaining vertical.

The movement vertically upwards is carried out by the superior rectus and the inferior oblique. The eyeball is slightly rotated inwards. The resistance opposed to this movement by the internal and external recti is greater than when looking downwards.

The movement vertically downwards is carried out by the inferior rectus and the superior oblique. The eyeball is slightly rotated outwards.

During horizontal movements of the eyeball rotation occurs round a vertical axis. Round this the axis of the cornea, supposing it to stand perpendicularly upon the centre of the vertical axis, can be turned inwards towards the median line, so as to describe an angle of from 42° to 51°, and can be turned outwards, so as to describe an angle of from 44° to 49°. The vertical meridian of the cornea remains vertical during these movements.

ACCOMMODATIVE MOVEMENTS.

The most frequent accommodative movement is convergence of both visual lines during reading, "near work," &c. The convergence is least fatiguing, and the reflex action of vision upon the recti muscles strongest, when the visual lines are at the same time directed somewhat downwards. The power of convergence increases when looking downwards, it decreases when looking upwards.

The power which the internal recti possess to turn both eyes inwards ("to converge the visual lines") varies in eyes otherwise healthy. Some are able to converge with ease to a point situated 1″ or 2″ from both eyes, while others can only converge to a point situated 4″ or 5″ from both eyes. (See Insufficiency of the internal recti muscles.)

Great convergence, if too long continued, produces muscular asthenopia.

The power of convergence and divergence, in other words, the strength of the internal and external recti muscles when responding to the act of binocular vision, can be measured with prismatic glasses. (See Insufficiency.)

Method of demonstrating the changes of position which the cornea, retina, &c., undergo during movements of the eyeball.

It has been repeatedly stated above that the vertical meridian of the cornea of one eye remains parallel with that of the fellow eye, especially during oblique movements of both eyes. The same is the case with the vertical meridian of the retina.

The movements and positions of the vertical meridians are ascertained in the following manner:—

A piece of red tape is stretched out vertically and level with the eyes upon a light grey background, the latter being divided into squares by horizontal and vertical lines crossing each other.

Standing at such a distance from the red tape as to avoid all perceptible convergence of the eyes, we look steadily at the tape for a few seconds. Looking then at some other part of the grey background, we perceive on

it a green image of the tape, which after a short time fades away. When we have once succeeded in producing this image, we find that however much we look horizontally or vertically, the image of the tape remains vertical in relation to the lines drawn on the grey background. Should this not be the case then the position of the tape must be altered until its image remains vertical during these movements.

The changes of position of the horizontal meridian are ascertained by producing a horizontal image of the tape.

On executing other than horizontal or vertical movements, we find that the image of the tape forms an angle with the lines on the background. This angle, which varies according to the degree of obliquity of the movements, can be measured. We can thus ascertain the extent of change of position of the horizontal or vertical meridian of the retina and cornea during oblique movements.

DEVELOPMENT.

About the end of the third month the muscles can be recognized as fine threadlike filaments. They are well marked about the fifth month, but appear inserted further behind the cornea, so that at that period the anterior two-thirds of the eyeball are in front of their insertion. At the apex of the orbit they are connected with one other by a reddish substance.

CONGENITAL ANOMALIES.

Absence of one, of several, or of all of the "recti muscles." Presence of all the muscles, the eyeball being missing. Abnormal adhesions of the muscles among themselves, e. g. of the obliqui to the recti muscles. Adhesion of the superior oblique to the trochlea. Abnormal length, or shortness, or thickness of the muscles.

NYSTAGMUS.

("TREMBLING OF THE EYEBALLS.")

Nystagmus signifies a peculiar involuntary movement of both eyes, which is the result of quick contraction of antagonistic pairs of muscles, or of entire groups of muscles.

Nystagmus may be continuous, or appear only during excitement, or when the eyes are brought into certain positions. It may disappear, or nearly so, during reading, and generally increases when the muscles are exerted by looking in rapid succession at different objects. The movement may be jerking, or oscillating in the direction of the recti muscles; or it may be rotatory round the axis of the oblique muscles; or a combination of both. The ordinary movements of the eyes are not interfered with.

Causes.—Nystagmus generally becomes developed during infancy. It has been observed to follow purulent ophthalmia. It is a common com-

plication of atrophy of the choroid (following choroiditis disseminata with or without opacities in the cornea), or of congenital cataract, or of both.

Vision.—The continuous movement of the eyeballs rarely gives rise to dimness, or uncertainty of vision. Cases have been observed in which distant objects appeared to move, and a few in which this has been the case with near objects also.

Some patients while reading counteract the nystagmus by movements of the head; the eyes then appear more steady. As soon however as the head remains quiet, e. g. when looking at distant objects, the nystagmus increases again. In most cases vision is impaired in consequence of the changes, of which the nystagmus is a complication.

Treatment.—Several cases have been benefited by altering the insertion of the recti muscles by operation.

LUSCITAS.

This term by some is applied to an oblique position of one or of both eyes, the mobility being lost entirely, or in part. Luscitas has been observed to accompany changes of shape of the eyeball; and also as a complication of orbital tumours, and of spasmodic and paralytic affections of the muscles.

Rare *anomalies of the action of the muscles* are—

(1.) Clonic spasm accompanying general (especially cerebral) diseases.

(2.) Tonic spasm, as part of a general spasmodic state in eclampsia, epilepsy, and after injury. The muscles are firmly contracted, the eyeball and the eyelids fixed, and the former drawn backwards into the orbit.

STRABISMUS ("SQUINT").

Strabismus is the inability to direct both eyes ("both visual lines") simultaneously to the same point of an object.

One visual line is directed to the object which the patient wishes to see distinctly, while the other deviates either too much inwards towards the inner canthus, producing Strabismus convergens; or outwards towards the outer canthus, causing Strabismus divergens. These are the most frequent forms of Strabismus.

Apparent strabismus may exist without real strabismus, i. e. the axes of the corneæ may diverge or converge too much, and yet the visual lines of both eyes may be directed properly. This apparent strabismus is, as a rule, but slight, and is the result of the too great or too small angle which the visual line makes with the axis of the cornea. This angle in the normal eye amounts to about 5°. We have apparent divergent strabismus, if it is greater than 5°, as is often the case in Hypermetropia; apparent convergent strabismus, if it is less than 5°, as is frequently observed in Myopia.

The degree of strabismus may be measured in the following manner. The patient is directed to look at an object held at 20″ from the eyes. A mark (*a*) is made on the margin of the lower lid of the squinting eye in a line with the centre of its pupil. The non-squinting eye is then covered ("excluded," but not closed), and the patient is directed to look with the other (squinting) eye at the object. A second mark (*b*) is traced on the same lower lid in a line with the pupil. The distance of *a* from *b* indicates the degree of the strabismus. If that distance amounts to 2‴, 3‴, or 5‴, we speak of a strabismus of 2‴, 3‴, or 5‴.

MOVEMENTS OF THE SQUINTING EYE AND OF THE FELLOW EYE.

The deviation of the visual line of the squinting eye, the visual line of the other eye being directed to the point of an object, is termed the primary deviation. The deviation of the visual line of the non-squinting eye, when covered (excluded) while the squinting eye is directed to the object, is termed the secondary deviation.

The secondary deviation being an associated movement, becomes less if the mobility of the squinting eye diminishes. In this case the patient often assists the eye by movements of the head.

The properly-directed eye, while looking at an object which approaches it, converges, while the squinting eye, if the object is brought very close, may remain fixed, or squint more, or deviate slowly or suddenly in a direction opposite to "the squint."

The patient may for a considerable time continue to direct the squinting eye properly when the other eye is excluded. In some cases this power is soon weakened or even lost. Vision becomes more and more impaired. Abnormal changes of structure (fibrous degeneration) occur in the unduly-contracted muscle and in its antagonist, leading to permanently impaired mobility. It is stated that if this fibrous degeneration has set in, the eye can still be directed to objects, but its movements under such circumstances are uncertain.

The strabismus is termed *concomitant* if the squinting eye accompanies the movements of the other one, except those of extreme inversion and eversion. In concomitant strabismus, the primary deviation is equal to the secondary, while in strabismus following paralysis, the secondary deviation exceeds the primary.

STRABISMUS CONVERGENS.

CONVERGENT OR INTERNAL STRABISMUS.

Causes.—(1.) The anomaly of refraction termed Hypermetropia is the most frequent cause. We very rarely err if, when meeting with convergent strabismus, we look upon it as one of the symptoms of Hypermetropia. About 95 out of 100 cases can be traced to this cause.

The origin of strabismus in hypermetropic persons is thus explained. To read or to look at near objects for a prolonged time requires a certain power of accommodation to keep up the necessary curvature of the crystalline lens, and a proportionate amount of power of the external muscles of the eyeball to maintain the requisite convergence. Accommodation and convergence go hand in hand. Strong accommodation is necessarily accompanied by strong convergence. Hypermetropic eyes, to be able to see distinctly, use more power of accommodation than emmetropic eyes, and simultaneously converge more. While reading type held at a distance of 12″ healthy eyes are directed to a point 12″ distant: but hypermetropic eyes to read at the same distance have to accommodate and converge strongly; and though the eyes are directed to a point which lies at 12″ distant there is a great tendency to converge for a nearer point, as may be seen if one eye is excluded, but not closed, while the other looks at the object. The excluded eye, as a rule, at once converges too much. If vision of both eyes is accurate, *then the tendency to use both* (*to maintain binocular vision*) is so strong that both remain properly directed, and no strabismus arises. Though even then we may find one of the eyes squinting for a few moments, just when commencing to read, and again when "the eyes get tired."

The occurrence of strabismus is facilitated by diminution of the acuteness of vision of one eye. The second eye, if only one is used, follows the tendency to too great convergence while the other is directed to the object. Diminished acuteness of vision of one eye may be the result of a high degree of Hypermetropia, or of alterations in the refracting media, e. g. opacities of the cornea, &c., &c.

Looking at objects placed laterally, or reading with the book held to one side so that only one eye is used, allows the other eye to follow the tendency to too great convergence.

The convergence of hypermetropic eyes is facilitated by the globular shape of the eyeball admitting of greater mobility, and particularly by the large angle which the visual line makes with the axis of the cornea. The greater this angle the more readily does the eye follow the tendency to strabismus.

(2.) Myopia.—The explanation, how Myopia can give rise to convergent strabismus is given under Myopia.

(3.) Inflammation of the internal rectus muscle occurring together with inflammation of the subconjunctival tissue.

(4.) Paralysis of the external rectus muscle, the convergent strabismus appearing as a later complication.

(5.) Disease of the brain, e. g. hydrocephalus; tumours in the orbit, displacing the eyeball, or impeding its movements.

General Remarks.—The strabismus which is connected with Hyperme-

tropia appears as soon as the patient uses the eyes much for near work, e. g. when learning to read. The strabismus at first is periodical, only appearing whenever the impulse to convergence is increased. Periodical convergent strabismus may continue for years, or it may become permanent soon after its appearance. Patients suffering from it, as a rule, are moderately hypermetropic. In such the acuteness of vision is much improved by excessive efforts at accommodation and convergence. The impulse to convergence is therefore greater than in higher degrees of Hypermetropia, in which even great efforts at accommodation do not improve the images on the retina much, and thus do not induce great efforts at convergence.

The strabismus having become permanent, is termed simple, if only one eye habitually deviates, which is usually the case. It is at the same time concomitant, if the squinting eye is properly directed, while the other, when excluded, squints in its turn.

The mobility outwards of both eyes is somewhat diminished, while the power of convergence is increased, and both internal recti are somewhat shortened.

If the strabismus is alternating, i. e. if sometimes one, sometimes the other eye squints, other causes besides hypermetropia must be looked for. Alterations of the contracted muscle may, if existing for many years, lead to loss of contractility through what is termed fibrous degeneration. The external rectus muscle at the same time undergoes atrophy.

Treatment.—Without an operation. Many cases of periodic, and even of permanent, strabismus occurring in Hypermetropics have been cured by the use of spectacles with convex lenses for near work as well as for walking, and by the application of atropia to the non-squinting eye, so as thoroughly to paralyze its accommodation.

The operation for strabismus should be performed if the treatment with atropia and spectacles has not succeeded within two or three months.

If for some reason the operation has to be postponed, e. g. in a child under the age of five years, we make the patient exercise each eye separately, especially the squinting one, by keeping the other eye closed for several hours every day. The acuteness of vision of the squinting eye is thus less likely to become deteriorated before the time for operation. Some recommend the use of spectacles with plane glasses: the glass corresponding to the better eye is tinted blue, so that objects appear of a pale blue tint, and the impressions on the retina become weakened.

Treatment by operation.—The immediate object of the operation is to alter the insertion of the tendon of the internal rectus muscle, and to retain the full length of the muscle. The tendon should be divided close to the sclerotic. After division, it recedes from its original insertion, and undergoes a new adhesion to the sclerotic. It has been stated that it may be made to recede as much as 3‴.

The muscle, before reaching the sclerotic, passes through the subconjunctival fascia and connective tissue. To these it is attached, as well as to the sclerotic. It recedes too much if it is completely separated from these attachments, or if divided behind them. The determination of the degree to which these attachments should be separated (to obtain the desired position of the eyes), constitutes the difficulty of the operation. In severe cases not only the internal rectus, but also the nearest part of the superior and inferior recti muscles, and the subconjunctival tissue intervening between them, may have to be divided.

The effect of the operation, besides immediately altering the position of the eyes, should be to weaken the contraction of the muscle.

The squinting eye only need be operated upon if the other, when excluded, does not deviate inwards while the squinting eye is directed to the object.

Both eyes should be operated upon if both squint, or if, the habitually squinting eye being directed to an object, the other eye when excluded deviates inwards. In this case we divide the tendon, and more or less of the subconjunctival fascia adjoining it in the habitually squinting eye, while in the fellow eye we only divide the tendon close to the sclerotic.

No operation should be proposed if the strabismus is connected with the causes given above under 2, 4, and 5, unless these causes have for a considerable time ceased to act.

Vision before the operation.

The accuracy of vision of most squinting eyes is defective previously to their squinting. Patients often remark that they see better when they "squint" with one eye, or while reading hold the book towards the side of the non-squinting eye.

A secondary diminution of vision always ensues if the strabismus continues for a long time. On the other hand, the weaker vision becomes, the less power does it exercise over the muscles of the eye.

The field of vision becomes more limited. The functions of the inner half of the retina of the squinting eye persist longest, and assist the vision of the fellow eye. The rest of the retina becomes more amblyopic. With increase of the deterioration of vision the eye gradually loses the power of looking steadily at an object. If this occurs, but little improvement of vision is observed after the operation.

The reason why diplopia is so rarely complained of seems to be that the strabismus often commences during childhood, when no attention is paid to the diplopia. Besides, the images of objects formed on the retina of the squinting eye are indistinct, and lie at some distance from the yellow spot, while the attention is occupied by objects directly looked at.

Vision after the operation.

One object of the operation is to restore a proper direction of the visual lines for all points of the field of vision, and thus to obtain as far as possible binocular and single vision.

Binocular vision is obtained in about half the number of patients operated upon for convergent strabismus. The results are more favourable the earlier the operation is performed. Much is already gained if binocular vision is obtained even for a limited range of the field. An increase of acuteness of vision from mere recognition of large letters before the operation to ability to read ordinary type immediately after it, is often observed. This is perhaps connected with a change which occurs in the ciliary muscle after division of the tendon of the internal rectus muscle.

Diplopia often appears immediately after the operation, but, as a rule, disappears spontaneously. It is more troublesome if the double image is slanting, or stands above, or behind the true one. If after from six to eight weeks it still persists, prisms may be tried. (See Diplopia.) Among a very large number of cases operated upon in which the position and movements of the eyes, and the acuteness of vision, and accommodation appeared normal, few cases have occurred in which a slight diplopia could in no way be removed by prisms.

Mobility of the eyes after the operation.

The separation of the muscle from its original insertion causes it to recede to an extent of from 1‴ to 3‴, and thus a diminution of the mobility of the eye towards the side operated upon is effected. This mobility having been too great towards the squinting side, a slight receding of the insertion is still compatible with normal, or nearly normal, mobility.

All movements are restored to the normal state in a small number of cases only. The result may be considered as satisfactory if both eyes are properly directed to an object placed at a distance of ten feet, and if they continue so while approaching the object to within 4 inches from the eyes; also, if on excluding one eye there is no deviation of the excluded eye. Parallelism of the visual lines for extreme convergence and divergence is rarely restored. If in from six to eight weeks after the operation, all other points of treatment having been observed, the eyes can only be brought to converge to a point situated 8 inches from the eyes and not nearer, divergent strabismus must be counteracted by subconjunctival division of both external recti.

The Operation.

Children and restless patients should be operated upon under chloroform

The patient lies on the back, the head being slightly raised and well steadied. The eyelids are kept open with the wire speculum. The eyeball is fixed by means of forceps. This is done by placing a pair of closed forceps perpendicularly upon it, near the inner margin of the cornea; then while pressing gently upon the eye the forceps are made to glide down to the spot where we propose to make the incision. There the forceps are allowed to open, and some of the conjunctiva and subconjunctival tissue is seized. Close to this, i. e. at the lower edge of the insertion of the internal rectus muscle, a small opening, about $\frac{1}{8}$ inch in length, is made into the conjunctiva and subconjunctival fascia with the blunt-pointed strabismus scissors, so as clearly to expose the sclerotic.

The strabismus hook is now passed through the incision along the sclerotic, and placed between the eyeball and the insertion of the muscle. If introduced properly, when we try to draw it forwards towards the cornea it becomes arrested at the point where the tendon is inserted into the sclerotic; while, if it has merely been introduced beneath the conjunctiva it can be drawn up to the margin of the cornea, beneath that membrane. The hook being placed between the tendon and the eyeball, the scissors are introduced through the incision, and the subconjunctival tissue is divided in front of the insertion of the muscle. The tendon is next divided close to the sclerotic, one blade of the scissors passing along the hook, and the other in front of the tendon. The gliding forwards of the hook beneath the conjunctiva up to the margin of the cornea is a sign that the tendon, or the part impeding the advance of the hook, has been divided. The hook should be repeatedly introduced, to ascertain whether the insertion of the tendon has been completely divided. Whether, and to what extent, the subconjunctival fascia adjoining the muscle may have to be divided is a matter of experience determined by the degree of strabismus. The eye which squints most is operated upon first.

Much blood occasionally is effused beneath the conjunctiva. An opening should be made at the most bulging part, to allow it to escape. From four to six weeks may elapse before it has all disappeared.

Cold applications to the closed lids for a few hours after the operation will be found grateful. No further treatment is required. The patient may go about the following day, and use the eyes, except for near work, reading, &c., which, however, may be allowed a week after the operation.

Among the accidents which may occur during the operation must be mentioned the wounding of the sclerotic, one of the blades of the scissors being thrust into the vitreous chamber. This grave accident is guarded against by the blades being blunt-pointed, and manipulated in such a manner as to cut along the surface of the sclerotic.

If after all undue vascularity and suffusion have subsided the strabismus reappears, in spite of the operation having been performed properly,

spectacles to remove the Hypermetropia should be worn for reading and other near work.

A second operation may have to be performed if the strabismus returns, and the impossibility of removing it by other means has been established. Sometimes it suffices at the second operation to divide the internal rectus muscle of the eye the vision of which is most acute. The range of movement being less, too great inversion of the fellow eye is prevented.

Should slight divergent strabismus follow, and the division of the external rectus be determined upon, the operation should be performed subconjunctivally on both eyes, and as soon as the divergence becomes evident; but not until all effused blood from the primary operation has disappeared.

Before operating a second time we ascertain whether with spectacles which neutralize the Hypermetropia for all distances, reading with both eyes is possible, the book being held at 6″ or 8″ from the eyes; if so, no operation is necessary, and the divergence must be attributed to the large angle which the visual line makes with the axis of the cornea.

Many, especially continental surgeons, divide the conjunctiva *over* the insertion of the muscle, instead of at its lower margin. They pass a small strabismus hook between the tendon and the eyeball, bring the insertion of the tendon into view, and then divide it close to the sclerotic. The wound in the conjunctiva is closed by a suture which runs from the angle of the wound next the caruncle to the one next the cornea. Thus the caruncle, which by this mode of operating is apt to sink back more than by the subconjunctival method, can be raised. Again, by enclosing more or less conjunctiva within the suture, the muscle can be drawn forwards while tying the suture, and, as is asserted, the point of its new insertion can be regulated. Those who adopt this mode of operating have laid down rules as to the cases in which it is necessary only to divide the muscle, and those in which the suture must be inserted.

About two-thirds of a line of conjunctiva enclosed by the suture on either side of the incision suffice to raise the caruncle without altering the position of the divided tendon.

The tendon may be carried back to its original insertion if much conjunctiva is enclosed in the suture.

The position and mobility of the eyes are tested immediately or a few hours after the operation; and the suture is loosened, or tightened, as may be required to regulate any faulty position, &c. In strabismus of $1\frac{1}{2}'''$ to $2'''$ no suture need be applied. In children the divided muscle recedes more, and a strabismus of from $2'''$ to $3'''$ requires no suture. In grown persons with strabismus of $2'''$ to $2\frac{1}{2}'''$ the insertion of the tendon must be exposed freely, some of the adjoining subconjunctival tissue be divided, and a

suture applied. In strabismus of 5‴ both eyes have to be operated upon; in the squinting eye, a strabismus of $2\frac{1}{2}$‴, and in the fellow eye one of $1\frac{1}{2}$‴ is corrected. A suture is inserted in each eye.

STRABISMUS DIVERGENS ("External or divergent Strabismus").

Causes.—(1.) *Anomalies of the functions of the muscles,* whether congenital, or following disease or operations (e. g. for convergent strabismus). Such anomalies are spasm, insufficiency, and paralysis.

The insufficiency may be the result of faulty shape of the eyeball; or of congenital weakness of the internal, or of undue power of the external recti muscles; or of the operation for convergent strabismus, causing too great receding of the internal rectus.

(2.) *Myopia.*—In every case of divergent strabismus we should ascertain whether myopia is present. It is the most frequent cause of divergent strabismus. The latter at first is but slight, and may remain stationary. If it increases, it does so slowly.

The increase of the myopia, i. e. the enlargement of the eyeball, gives rise to difficulty of convergence. The images of objects which are placed at equal distances from both eyes are less perfect on the retina of the more myopic eye. Vision of one eye being less perfect, the impulse given by binocular vision to maintain the convergence of the eyes is weakened, and the divergence of the weaker eye facilitated.

The eyeball which resists the converging power most, soonest induces fatigue of that power; and the eye diverges the quicker the more convergence is required, as in reading, or other near work. The attempts of the "converging" muscles to maintain binocular vision lead to fatigue, and the eye rests itself by diverging.

The divergence is facilitated by the smaller angle which the visual line forms with the axis of the cornea.

(3.) *Impairment of vision.*—An eye the vision of which is impaired to such an extent that it no longer assists the fellow eye in near work, reading, &c., may become divergent whatever be the state of its refraction. The anomaly of refraction may be the cause of the impairment of sight, and thus indirectly the cause also of the divergence.

It has been observed that all other parts being normal, no divergence has occurred through the retina of one eye being amaurotic in the region of the yellow spot, if the peripheral parts of that retina have remained sensitive.

Amaurosis, whatever be its cause, if confined to one eye, is generally followed by divergent strabismus. This not unfrequently occurs in both eyes, if both are amaurotic. The internal recti are no longer excited to contraction, and their power gradually decreases.

Divergent strabismus, including slight cases, is as frequent as converg-

ent strabismus. In 90 per cent. of cases it is a complication of myopia. It is generally confined to one eye. The most extreme forms occur after long-continued paralysis of the internal rectus muscle, and after operation for convergent strabismus.

GRADATIONS OF DIVERGENT STRABISMUS.

(1.) Alternating relative divergent strabismus. After maintaining both eyes properly directed for some time, one eye diverges through its internal rectus becoming fatigued. After rest, the convergence can again be maintained.

(2.) Relative divergent strabismus. — The power of convergence, when looking at near objects remains insufficient, while it continues undisturbed when looking at more distant objects. The relation between convergence and binocular vision is only disturbed for certain distances. When looking at distant objects this may be combined with convergent strabismus as the result of impaired functions of the external recti muscles. In high degrees of myopia, in which objects must be held very near to be seen distinctly, the convergence of the eyes is often imperfect, and relative divergent strabismus is the rule.

(3.) Absolute divergent strabismus. *At no distance* can both eyes be brought to converge to the same point. The divergence exists for all distances, though it may diminish when one eye looks at near objects. Neither binocular vision, nor attempts towards it, longer exist.

The diverging eye may be blind, or at least not participate in binocular vision. Comparatively few myopic eyes with relative diverging strabismus become absolutely diverging. Paralysis of the internal rectus muscle—unsuccessful operation for internal strabismus—and especially amaurosis—furnish a large number of cases of absolute divergent strabismus.

Treatment.—If the diverging eye is blind, or can only perceive large objects, no benefit is derived from treatment by optical means. It may, to improve the patient's appearance, become desirable to make the diverging eye assume a position similar to that of the normal fellow eye when looking at objects from 5 to 15 feet distant. This position in slight cases is obtained by dividing the conjunctiva, subconjunctival tissue, and the tendon of the external rectus muscle of the diverging eye. If this does not produce the desired effect, we divide the conjunctiva and subconjunctival tissue as far as the nearest margins of the superior and inferior recti muscles, and likewise, but subconjunctivally, the tendons of these two muscles. Should this not succeed in restoring the required position, then the tendon of the internal rectus has to be divided also, and the end of the tendon, which remains attached to the muscle, has to be stitched to the conjunctiva and subconjunctival tissue nearer the cornea.

To secure the new attachment of the tendon, a large portion of the conjunctiva and of the subconjunctival tissue must be enclosed in the suture, and care must be taken while tying the suture that it does not give.

The eye, after these operations, must be kept closed until all "redness" has disappeared. Lint dipped into cold water is applied frequently to the closed eyelids of both eyes for two days after the operation.

It is better not to administer chloroform while our operations remain confined to the external, superior, and inferior recti muscles. If the position obtained is not satisfactory, then chloroform is given, and we proceed to the division, &c., of the internal rectus muscle.

If with the diverging eye the patient can recognize large letters, or even read small type, the operations described above can also be recommended, provided the eyes are not myopic.

If the diverging eye is myopic, some advantage as regards position when looking at distant objects is derived from division of the tendon of the external rectus muscle.

Some advise, if one myopic eye is used for reading, and the diverging fellow eye for distant objects, not to operate, but to allow the patient to continue using the eyes in this manner. (See treatment of Myopia, and of Insufficiency.)

PARALYSIS AND PARESIS.

Causes.—Paralysis and paresis may be the result of morbid changes:—

(1.) Implicating the nerves of the muscles; (2.) occurring in the muscles themselves; or, (3.) affecting both simultaneously.

The causes may be classed according to the seat of the lesion which gives rise to the paralysis.

Intercranial and cerebral causes.—In these the paralysis is often complicated with impairment of memory or of speech, with paralysis of other nerves, with anæsthesia, &c.

Paralysis progresses rapidly in plastic effusions at the base of the brain. Several muscles in both eyes, or several in succession, become paralysed.

Ptosis is frequently, lagophthalmos only exceptionally, present.

Paralysis of the third, fourth, fifth, and sixth nerves with hæmorrhage into the retina has been observed, in the course of aneurism of the arteria cerebralis posterior.

The third nerve where it emerges from the brain is surrounded by numerous arteries. Its paralysis is rarely complicated with hemiplegia.

Orbital causes.—Periostitis—abscess—tumours (neuroma, exostosis, &c.)—effusion of blood. (The passage of the nerves through narrow fissures, the numerous blood-vessels near the nerves, and the attachments of the muscles near each other, favour the occurrence of paralysis if morbid changes become developed in the orbit, or at its inlets.)—Inflammation

of the subconjunctival fascia (of Tenon's capsule), (accompanied by pain round the orbit, and when moving the eye).

Injuries.—The operation for strabismus, followed by divergence of the eye in the direction of the antagonist. (Both muscles may undergo secondary changes, the divided muscle becoming atrophic, and its antagonist "fibrous.")

Destruction of the muscle by suppuration.

Distension of the muscles by protrusion of the eye.

Atrophy of the muscles (congenital, or through some of the above changes.)

Syphilis, in one half of the cases, is found to be the primary cause.

Mobility of the affected eye.—We distinguish between impaired (paresis) or completely arrested mobility (paralysis) of the eyeball in one, in several, or in all directions. Those acquainted with the functions of the muscles in health will have little difficulty in determining which muscle or muscles are affected when the patient is unable to make the eye assume any desired position.

Paresis of one, or of several muscles, readily becomes apparent during accommodation for near objects, during reading, &c., in which case all muscles are required to act. A morbid deviation soon arises in the direction of the antagonist of the paretic muscle.

Symptoms of fatigue appear in Paresis in the impaired muscle first, if, while the patient holds the head steady, and only moves the eyes, we make him look at an object held in succession in different parts of the field of vision. The fatigue becomes the more evident the longer such experiments are continued; in other words, the more the affected muscle is taxed. The eye, in well-marked cases, can only follow the object up to a certain point, when the movements become jerking or uncertain. The eye finally deviates in the opposite direction.

When we "exclude" the normal eye, and watch its movements behind the hand, we find that, while the paretic eye looks steadily at an object, the simultaneous movement ("the deviation") of the excluded normal eye is greater than that of the paretic eye. The same effort of the will acting upon the muscles of both eyes, the one with the weaker ("paretic") muscle responds to it by a lesser movement. The paretic muscle, to direct the eye to an object, requires a stronger impulse of the will (a stronger innervation). The same impulse, acting upon the healthy muscles of the fellow eye, gives rise to too great deviation of the healthy eye. The deviation of the impaired eye is termed primary, that of the normal eye secondary. In the degree of the two deviations we possess a means of measuring the paresis. For example, if the left external rectus muscle is paretic, we exclude the right eye, and cause the left to look at an object held towards the left side. We then find that, to make the left ex-

ternal rectus muscle carry out the necessary contraction, an innervation (an effort of the will) is required which is much stronger than the one which would be required for the same contraction in health. The effect is, that the same impulse being given to the muscles of the normal fellow eye to carry out the necessary associated movement inwards, this movement becomes too great, and the eye squints inwards. Another illustration of difference of contraction of two muscles under the same effort of the will, is afforded by paresis of the superior rectus, while the levator palpebræ of the same eye remains intact. When looking upwards the upper lid of the affected eye appears raised more than that of the fellow eye, in consequence of the paretic upper rectus muscle not being able to respond to the impulse of the will to the same extent as the "levator palpebræ."

Strabismus may develope itself as the result of changes in the paralysed muscle, and contraction of its antagonist. Paresis or paralysis of one eye may induce strabismus of the fellow eye, if the vision of the affected eye be the more perfect. The efforts to direct the visual line of the affected eye to the object give rise to too great associated contraction of the muscles of the fellow eye, and finally to strabismus. Paralysis may lead to strabismus, through the non-paralysed muscles altering the position of the eye so as to remove troublesome diplopia, i. e. to cause the double image to fall on a more eccentric part of the retina.

All trace of paralysis having disappeared, concomitant strabismus may remain. In this case, the usual operation for strabismus is performed.

Vision.—The anomalies of vision usually observed are:—Diplopia—impaired judgment as regards the position of objects—and amblyopia, if the paralysed eye has not been used for a considerable time.

In fresh cases of paralysis, as long as no attempt is made to call into action the paralysed muscle, no *Diplopia* is observed. In cases of long standing, with morbid convergence or divergence, secondary contraction of the antagonist of the paralysed muscle often occurs, which may give rise to the diplopia extending over a large portion of the field of vision. This secondary contraction appears to occur sooner, if, previous to paralysis, vision has been impaired, or if there is great difference of refraction of the eyes.

Some patients avoid the diplopia by keeping the lids of the affected eye closed. Or they assist the paralysed muscle by moving the head, e. g. by turning it towards the right side, if the right eye cannot look in that direction. Holding the head in peculiar positions assists the affected eye in avoiding those movements which would require a contraction of the impaired muscle.

The symptom diplopia is sufficient to enable us to determine which muscle is paralysed, and to what degree.

In order to find in slight cases which eye is affected, we direct the

patient, while he looks at an object, to close the eyes alternately, when the image of the object belonging to the affected eye is described as moving. In slight diplopia the images partly cover each other, or the objects appear surrounded with a halo. To facilitate the distinction of the images, we make the patient look through a slip of red glass placed before the normal eye. This causes one image to appear coloured red, and less brilliant. The double image is the less striking the further it lies from the yellow spot.

The double image is seen at a spot opposite to the one which it occupies in the retina, e. g. if the eye deviates upwards, the image is formed on the upper part of the retina above the yellow spot, and is seen by the patient below the image seen by the normal eye.

Diplopia from paralysis of the oblique muscles persists for a long time, and can by the aid of the tinted glass easily be made perceptible to the patient.

The judgment as regards the position of objects is impaired. The patient, on closing the normal eye, and using the affected eye only, misses an object when attempting to touch it quickly, if the object be held in the part of the field of vision which would require the help of the paretic or paralysed muscle to direct the visual line. The power of localising objects in the field of vision depends chiefly upon the sensation of contraction of the muscles of the eye. The insufficiently innervated muscle requires a much stronger impulse of the will to effect a certain movement than would be required in health to effect the same amount of movement; and the patient, misled by the strength of the impulse, overestimates the contraction effected by the impaired muscle, believes the object to lie more towards the side of the impaired muscle, and aims too much towards that side.

This symptom disappears after the impairment has existed for some time. The judgment as regards the position of the field of vision, and of the objects in it, becomes altered gradually.

The difference between the imaginary and the real position of an object gives rise to the sensation of dizziness; and the patient, with the normal eye closed, when quickly walking towards a fixed object, turns towards the side of the paralysed muscle. The dizziness is greater if the diplopia is but slight.

General remarks, especially on Paralysis of the third nerve.

Paralysis of all the muscles of the eye is generally a complication of cerebral or spinal disease. The paralysed eyeball is slightly protruding and immovable. The visual line is directed straight, or slightly outwards and downwards. The iris and the ciliary muscle are paralysed. The upper lid is drooping.

The muscles most frequently paralysed are those supplied by the third and sixth nerves.

Paralysis of the third nerve frequently extends over all its branches. The paralysis may affect only part of a muscle, or one or several muscles in each eye. If complete it is combined with ptosis, which is still more considerable if the orbicularis muscle is also paralysed. The eye diverges slightly. It cannot be directed inwards (paralysis of the internal rectus), it cannot be directed upwards (paralysis of the superior rectus and of the inferior oblique, which latter is less frequently implicated). When attempting to look down the superior oblique alone acts, rotating the eye slightly inwards, the inferior rectus being paralysed. The pupil, as a rule, is dilated, and further dilatable by atropia. The ciliary muscle is generally impaired, and often paralysed.

Secondary contraction of the external rectus soon follows, causing "divergent strabismus." Vision with both eyes is at first much disturbed. The affected eye diverges when steadily looking at an object placed in the median line, the normal eye being closed. Great dizziness is complained of.

In paralysis of the third nerve, the double images, when looking straight forward, are crossed; the false image stands somewhat lower, with its upper end inclined towards the normal eye. The inclination increases when looking upwards, and becomes greatest on looking upwards and outwards. The difference in the lateral distances of the images increases with increasing deviation of the object towards the side of the normal eye. The difference in height increases when raising an object above the horizontal line; and decreases on lowering the object below that line, or when looking outwards and downwards. The action of the superior oblique may cause this difference to disappear. Objects during attempts at accommodation appear smaller, and nearer the affected eye.

Prognosis and treatment.

The prognosis of Paralysis or of Paresis is more favourable, if syphilis or rheumatism is the cause,—if the cause lies within the orbit,—if the paralysis is fresh,—or if there is only paresis;—or if the double images stand side by side without any difference in their height. The prognosis is bad if long duration has led to atrophy of the nerves or muscles, with or without contraction of the antagonists.

The general medical treatment depends upon the cause.

Locally we have to attend to the inconveniences which arise—from the diplopia,—from the impairment of vision,—and from the impairment of mobility and its consequences, e. g. secondary strabismus, insufficiency, &c.

The diplopia is generally troublesome if vision of both eyes is acute, and the double images stand close to each other.

If there is paralysis the inconvenience arising from diplopia is obviated

by keeping the affected eye closed, or by wearing spectacles with a tinted glass for the paralytic eye.

In paralysis of the superior oblique (the inclined retinal image being above, and internal to the yellow spot) the diplopia may be removed by placing in front of the eye a prism with the refracting angle upwards and slightly inwards. If the inclination of the retinal image is too great it may suffice to remove by prisms the lateral distances of the double images.

If there is a difference in the lateral distances and in the heights of the images, the image of the affected eye standing lower, we remove the difference in height by placing a prism with the refracting angle upwards before the affected eye. A second prism with the refracting angle inwards is placed before the normal eye, if the difference of the lateral distances is not removed by spontaneous contraction. This prism induces a convergence of that eye and an associated movement outwards of the fellow eye, thus uniting the still laterally displaced images.

The treatment of diplopia from paresis is adopted if the deviation, and with it the distance of the double images from each other, is so great that no discomfort is felt, or if the affected muscle has regained some contractility.

If there is paresis, the affected eye should be used frequently alone so as to practise the paretic muscle, while the normal eye is kept closed. Prisms may be tried to bring the double images near each other, and thus to excite contraction of the paretic muscle to unite the images. The prism suits if it enables the eyes to see single without there being a sensation of straining. The prism at first should be used for objects situated not nearer than 10 feet from the eyes. Less contraction of the muscles is required at that distance, and also at greater distances. The prism, if too weak or too strong, may cause contraction of the antagonist of the paretic muscle. If the prism is too weak the distance of the double image from the yellow spot remains too great to be overcome by contraction of the paretic muscle; and instead of contraction of the paretic muscle, contraction of its antagonist ensues to remove the diplopia.

If no tendency exists to unite the images, or if this tendency is very slight, or if stronger prisms than of 14° are required to bring the images near each other, then prisms must be given which completely unite the images, the refracting angle being directed inwards in paresis of the external rectus, and outwards in paresis of the internal rectus.

If these remedies do not remove the diplopia, the paresis or paralysis having existed for two months or more without any contraction of the antagonist having followed; then an operation may be recommended, the result of which is better if the contractility of the affected muscles is good. Tenotomy of the antagonist of the affected muscle should be performed, and have the effect of producing single vision for near work.

If this result is not produced, and diplopia continues during reading, then, in addition to the first operation, tenotomy of the paretic muscle should be performed and its tendon should be attached nearer the cornea.

The object of these operations is to assist the contraction of the affected muscle by advancing its insertion, to weaken its antagonist by carrying its insertion further backwards, and to remove the diplopia as much as possible, especially for reading, &c.

Cases have occurred in which the double images, though close to each other, could not be made to unite. This was attributed in some to cerebral changes, in others to an anomaly of accommodation.

In paralysis which has existed for a considerable time (for two months and longer), satisfactory results have been obtained from the use of electricity.

Paralysis of the internal rectus muscle (*branch of the third nerve*).

Symptoms.—Movements.—The inward movement of the affected eye is impossible as far as the internal rectus is concerned. A slight inward and downward movement is effected by the combined action of the superior and inferior recti muscles. The eye diverges sooner when looking upwards than when looking downwards.

In paresis the associated movement of the external rectus of the normal eye, when excluded, is too great. The patient, to avoid the diplopia, turns the head towards the side of the normal eye.

Vision.—Diplopia appears when looking towards the side of the paralysed muscle. The line, dividing the field of vision in which diplopia is observed, is not vertical but oblique, running from without and above, inwards and downwards. The double images are crossed, level and parallel with each other. Their lateral distances increase the more the more the object looked at is placed towards the side of the unaffected eye. The double image, instead of remaining parallel with that of the fellow eye when looking obliquely upwards or downwards, remains vertical, while the image of the unaffected eye is inclined outwards. The height of the images differs through the vertical meridian of the affected eye being inclined outwards, although the height of the cornea appears unaltered. The image is formed on a part of the retina external to and above the yellow spot, and therefore is seen internal to and below that of the fellow eye. A prism held before the affected eye with the refracting angle directed outwards unites the images.

Paralysis of the inferior rectus muscle (*branch of the third nerve*).

Symptoms.—Movements.—The eye cannot be directed downwards; and when attempting to do so it turns outwards and upwards. Even when looking at objects placed horizontally the eye already deviates slightly

outwards. The paralysis makes itself most felt when attempting to look downwards and outwards.

In paresis, when excluding the normal eye and directing the paretic eye downwards and inwards, a greater associated movement of the excluded eye downwards and outwards is observed.

Vision. — Diplopia appears when looking downwards. The double images are crossed. The one of the affected eye stands deeper, lies on the side of the normal eye, and is inclined towards the median line (towards the image of the normal eye), thus the upper extremities of both images stand nearer each other. The obliquity of the images and their height increases the more the object is moved inwards and downwards. The image is formed on the retina above the yellow spot, and is therefore seen below that of the normal eye. The refracting angle of a prism, to unite the double images, has to be held upwards and slightly outwards. The patient when attempting to touch an object passes beneath it.

Paralysis of the superior rectus muscle (*branch of the third nerve*).

Symptoms.—Movements.—The affected eye when trying to look upwards deviates slightly outwards and downwards, through the action of the inferior oblique being no longer opposed by that of the superior rectus.

In paresis, when raising the visual line above a certain height, an unnatural rising of the lid is observed, i. e. more of the sclerotic is exposed on the normal than on the paretic side. The associated movements of the excluded healthy eye upwards and outwards are too great when the paretic superior rectus muscle acts.

Vision.—The patient when striking at an object aims too high.

Diplopia appears on looking upwards. The images of objects fall on a part of the retina which lies outwards and downwards from the yellow spot. The double images are crossed, and do not stand parallel. The inferior oblique being unopposed, the vertical meridian is inclined outwards, and the crossed double images diverge above. This obliquity increases during divergence. The height of the image increases when the eye diverges, and decreases during convergence.

Paralysis of the inferior oblique muscle (*branch of the third nerve*).

Paralysis very seldom affects this muscle alone. The affected eye when attempting to look upwards deviates downwards and inwards.

Vision.—Diplopia only appears when the object is raised above the horizontal median line; it is homonymous, the double image at the same time standing higher, and being inclined inwards. The position of the double image is most striking when the object looked at is moved in a direction opposite to that of the affected eye; while its inclination

increases when the object is moved outwards, towards the side of the affected eye.

Paralysis of the superior oblique muscle (*fourth nerve*).

Symptoms.—Movements.—The affected eye, when looking at an object placed in the horizontal median line, deviates slightly inwards and upwards. The deviation increases when the object is moved downwards. The eye deviates outwards if the object is held above the horizontal median line. The affected eye moves downwards and outwards when the fellow eye is excluded, while the latter makes a stronger associated movement downwards and inwards. Secondary contraction of the inferior oblique ensues if the paralysis persist for a long time; and the cornea of the affected eye comes to stand higher during all movements.

Vision.—At first objects seem to move, and one eye has to be kept closed when reading. This is soon followed by well-marked diplopia, which especially appears when looking downwards. In fresh cases the diplopia is confined to the half of the field of vision which is situated below the horizontal plane, while in cases of long standing it extends over the entire field. The double image is homonymous (lies on the side of the affected eye), if the object, the image of which is formed on the retina inwards from and above the yellow spot, is held below the horizontal median line. If the object is held above that line, the double image is crossed (divergent strabismus), stands deeper, and is inclined outwards.

Diplopia, with strabismus, when looking downwards, is the chief symptom of this form of paralysis.

The differences in height, inclination, and distance of the images increase when the object is moved downwards in the median line. Moving it in the lower half of the field of vision towards the side of the normal eye causes a decrease of the lateral distances and of the inclination, and an increase in the height. The double image appears above the normal one if the object is held far down in the lower half of the field, though the cornea of the affected eye stands higher. Moving the object in the lower half of the field of vision towards the affected eye causes a rapid decrease in the height of the images and in their lateral distances, while their inclination increases. Through excessive inclination of the vertical meridian one image appears to lie nearly above the other. The patient when attempting to touch an object quickly, misses it, and strikes too low and towards the side of the affected eye.

The double image appears to be nearer than that of the other eye. Some describe it as appearing bent, or its upper part further distant than the lower one. In fresh cases the head is held forwards to cause the double image to be seen in the upper half of the field of vision.

Paralysis of the external rectus muscle (*the sixth nerve*).

Symptoms.—Movements.—The affected eye cannot be directed horizontally outwards. The attempt to do so gives rise to an irregular jerking movement caused by the alternating action of the superior and inferior oblique, the former drawing the eye downwards and outwards, the latter upwards and outwards. An abnormal convergence appears when looking upwards, though less than when looking downwards, or straightforwards. The convergence is the greater the more an object is held towards the side of the paralysed muscle.

Vision.—Diplopia appears when, without moving the head, the patient looks at an object placed in that half of the field of vision which lies next the paralysed muscle.

The double images are not crossed, but stand parallel to each other, and side by side. Their distance from each other is the greater the more the object is moved in a horizontal direction towards the side of the paralysed muscle. When looking outwards and upwards the double image stands higher and is inclined inwards. It stands deeper, and is inclined outwards, when looking outwards and downwards. The patient, to avoid the troublesome diplopia, turns his head towards the opposite side, and holds objects towards the side of the paralysed muscle. When quickly striking at an object held into the half of the field of vision next the paralysed muscle, he misses it by striking too much towards the side of the affected muscle.

INSUFFICIENCY OF THE INTERNAL RECTI MUSCLES.

(*Insufficiency of the converging power of the Eyes.*) (*Asthenopia muscularis.*)

If we place a prism of 3° (see Prisms) with its refracting angle inwards, e. g. before the right eye, both eyes being open and looking at the same point, say at a letter of No. xx., placed at 20′ from the eyes, we for a moment see double; we see with the right eye the letter in another direction, through its image being formed on a part of the retina external to the yellow spot. To remove the diplopia we involuntarily alter the position of this eye (the direction of the visual line) by increasing its convergence (by squinting). We thus cause the image of the letter to be formed at the yellow spot. This power of increasing the action of a muscle, to remove or to avoid diplopia produced by prisms, is termed the power of overcoming a prism (in our case one of 3°).

Both eyes have a desire for single vision of objects directly looked at, and the images of objects when formed in one eye upon a part near the yellow spot, while in the other eye the same images are formed at the yellow spot itself, induce in the first eye the desire for single vision.

The desire for single vision is greatest if the images are level with each other and homonymous (see Diplopia); it is less strong if they are

crossed; and it is very slight or altogether absent if one image stands higher than the other.

If the eyes do not succeed in uniting the images, one or both may move in opposite directions, thus causing the images to be formed in a portion of the retina which is more remote from the yellow spot. The images, standing further apart, are less troublesome, and therefore the desire of uniting them disappears.

It has been found by experiment that the strongest prism which can be overcome by increased convergence is one of 30°, and by increased divergence one of 6°. The superior and inferior recti can only overcome prisms of 1° or 2°. It therefore follows that prisms of certain degrees, with the refracting angle directed horizontally inwards, in order to avoid diplopia, must produce convergent strabismus. If the refracting angle is directed horizontally outwards, divergent strabismus is induced for the same purpose. In the former case the image is displaced upon a part of the retina situated external to the yellow spot, and the latter to receive the image has to be displaced outwards, which is accomplished by contraction of the internal rectus. The reverse occurs if the image is displaced upon a part of the retina situated internal to the yellow spot. The latter has to be drawn inwards to meet the image, which is accomplished by contraction of the external rectus. Artificially produced divergence sometimes influences our judgment as regards the distances and sizes of objects; the latter appear larger when seen through the prism, because less convergence is required. On removing the prism, after having held it before the eye for a considerable time, increased contraction of the muscle, with diplopia, continues for some time.

Insufficiency of the internal recti muscles signifies want of power of these muscles, their action not being adequate to the requirements of binocular vision. The power of contraction is most taxed during "near work," reading, &c., and it is then that the symptoms of insufficiency become first apparent. In insufficiency the associated movements of both eyes are normal, not so in paresis.

The subjective symptoms of the insufficiency are in a great measure those of asthenopia, and in every case of asthenopia we should ascertain the power of the internal recti muscles. The asthenopia caused by insufficiency is termed "Muscular Asthenopia" (See Asthenopia). To establish the existence of insufficiency we must compare the converging power with that of the eyes in health.

Healthy eyes can converge towards an object placed at 3″ from the eyes, and can maintain that degree of convergence for a short time.

If one eye suffers or if both eyes suffer from insufficiency, then the weaker of the two eyes diverges; or both diverge, if both are affected. The "weaker eye" diverges first, or, when excluded, deviates sooner outwards.

We suppose the insufficiency to be pretty equal if at one moment one, at another the other, eye diverges. The insufficiency is the greater the sooner divergence occurs, when bringing an object near to the eyes. It is already great if it appears when the object is placed at 6″ from the eyes.

If both eyes for a prolonged time are directed to an object held at 8″ or 10″ distance (the hand or a shade being placed before one eye, so as to prevent its seeing the object (to "exclude the eye"), and yet so as to allow us to watch the excluded eye), and if we find that the latter diverges, we infer that the converging power of that eye is insufficient.

We establish the existence of insufficiency still further by tracing on white paper a vertical line with a dot in the middle, placing the paper at from 12″ to 15″ from the eyes, and in the position in which, when reading, a book would be held. We direct the patient not "to strain the eyes," and chiefly to look at the dot. We then place a prism of 15° with the refracting angle directed upwards before one eye. Double images are produced, which, if there is no insufficiency, stand one above the other, and two dots are seen, one above the other, on one vertical line. We know from experience that, as soon as single vision is destroyed by the prism thus held, the contraction of the recti muscles, if abnormal, ceases. If insufficiency of that eye exists which looks through the prism, then the contraction of its internal rectus becomes less, and the eye diverges. The double images recede from each other in a lateral direction, and the two dots, instead of standing upon the same line, are seen each on a separate line. The lines stand parallel with each other, and the line and dot which stand lower belong to the eye which looks through the prism.

This displacement of the dots and lines can be removed by holding a second prism before the first one, with the refracting angle outwards. This second prism must be the stronger the greater the deviation, i. e. the insufficiency; and the degree of the latter may be expressed by the strength of the second prism. The greater the insufficiency the greater is the lateral displacement of the double image, and the stronger must be the prism which unites the two images.

Having ascertained the degree of insufficiency for reading distance, we ascertain it for greater distances, using, instead of a dot, the flame of a candle. Both eyes should thus be examined. At last we remove the first prism and determine what prisms, when looking at a distance, can be overcome by convergence, the refracting angle of the prism being held inwards; and what prism can be overcome by divergence, holding the refracting angle outwards.

The power of divergence is in these cases generally much greater than that of convergence; so that in the same eye by divergence a prism of 30° may be overcome, by convergence only one of 5°. If therefore we find that

the diplopia, produced by a prism of more than 6°, held with the refracting angle outwards, can still be removed by divergence, we may at once suspect insufficiency of the internal recti muscles.

Causes.—Faulty shape of the eyeball, as in myopia, or weakness of the internal recti muscles, or both.

The weakness of these muscles is often congenital and hereditary.

Treatment.—Having established the existence of insufficiency, we often succeed in removing the asthenopia caused by it by optical or surgical means, or by a combination of the two. The mode of treatment is modified by the state of refraction, which should be ascertained.

(1.) *In case the refraction is normal, and the eyes are otherwise healthy.* If, while excluding one eye, the other looking at a distant object, we find that the excluded eye diverges to the extent of 1‴ to $1\frac{1}{2}$‴ from the position which it occupied before exclusion for reading and near-work, we recommend spectacles with prismatic glasses, the refracting angle being turned outwards.

The prisms, thus placed, displace the image upon a part of the retina which lies internal to the yellow spot. To avoid diplopia, the external recti muscles must be made to contract, and the internal ones to become relaxed. The yellow spot of each eye is thus moved to the spot where the image of the object is formed. Less convergence is required, and the fatigue due to insufficiency is sometimes removed.

If, as in paresis of the internal recti muscles, it is desirable to excite and practise contraction of these muscles, we reverse the position of the prisms.

We give prisms of equal strength to both eyes.

If the strength of the correcting prisms exceeds 10° or 12°, we divide the external rectus of the eye which diverges most on exclusion.

We divide both external recti muscles if in each eye the outward movement exceeds an angle of about 6°. Prisms, by diminishing the effort of convergence, also diminish the effort of accommodation, and patients often judge of distance wrongly, and state that objects appear larger.

(2.) *In case the eyes are myopic.* In the higher degrees of myopia insufficiency almost always exists; and often, after continuing for some time, is followed by divergent strabismus of the most myopic eye.

We may suspect insufficiency if the acuteness of vision is normal, and if the eyes of the myop, when looking at a distant object, diverge. We may, however, find the eyes standing parallel, or even converging slightly, when looking at a distance, and yet, on examination, meet with divergence of one eye while reading.

Slight insufficiency may be removed by making the patient work with spectacles with concave lenses, which allow of the work being held further from the eyes, thus requiring less converging power, e. g. we find that a myop (of $\frac{1}{10}$) without using spectacles when reading holds the book at 8″

from the eyes, and suffers from asthenopia. On examination we discover, at the distance of 8″, an insufficiency of 10°; while when he holds the book at 10″ the insufficiency is reduced to 5° and he can read with ease. We give him spectacles with lenses of $-\frac{1}{40}$, which enable him to read with comfort at 10″. The convergence required for that distance taxes the power of the internal recti muscles less, and no more asthenopia is complained of.

Before having in myopics recourse to prisms, or prismatic concave lenses, we should try to counteract the insufficiency by altering the distance from each other of the spherical concave lenses used for reading.

Less convergence of the eyes ("of the visual lines") is required if, during reading, &c., the centre of one concave lens stands further apart from the centre of the other than the centre of one pupil from that of the other. Spectacles with the concave lenses thus displaced must not be used for looking at a distance, since in doing so they give rise to divergence of the eyes, and thus weaken the internal recti muscles still more.

If these spectacles when used for reading fatigue the eyes, it may arise from the insufficiency being too great, or from one eye not previously having been used while reading. The efforts of the latter to maintain distinct binocular vision become fatiguing.

In such cases prismatic concave lenses (the refracting angle directed outwards) should be tried, provided the state of the eyes does not otherwise prohibit the use of spectacles. Reading with the spectacles should not, when excluding one of the eyes, be accompanied by divergence of the excluded eye.

(3.) *In case the eyes are hypermetropic.* The asthenopia can sometimes be removed by altering the spectacles, causing the convex lenses (their centres) to be placed nearer each other than the centres of the pupils during reading. For example, if we find that one of the patient's eyes, while reading, diverges when excluded, we ascertain by experiment that distance of the lenses from each other which admits of the patient's reading without divergence.

When selecting for our patient the combination of a prism with a spherical lens, we must first find the necessary spherical lens, whether convex or concave. This lens being placed into the spectacle frame, we make the patient read at the distance for which we propose the spectacles to be used. In another spectacle frame we insert the prism, which is then held in front of the spherical lens. We have to ascertain by experiment which prism is required to produce the desired degree of convergence of the eyes. The optician then has to combine the prism and the spherical lens into a spherico-prismatic lens.

In hypermetropics however two causes of asthenopia exist, the most

frequent of which is the undue contraction and too quick exhaustion (asthenopia) of the ciliary muscle. The asthenopia occurs the sooner the less readily contraction of the ciliary muscle can be exerted. This is the case if the power of convergence becomes diminished by approaching the convex lenses of the spectacles close to each other. In such cases the remedy for the muscular, more readily developes the accommodative asthenopia. For reading we may try spectacles with a combination of a prism with each convex lens, taking care to order the convex lens stronger than would be given to hypermetropics without insufficiency.

Division of one or of both external recti muscles is indicated if such spectacles do not remove the muscular asthenopia. The operation may have the effect of making spectacles with common convex lenses suffice.

Treatment by operation, i. e. by division of one or of both external recti muscles.

The object of the operation is to facilitate the contraction of the internal recti muscles, and to weaken that of the external recti muscles.

The operation is indicated if, e. g., we find that the divergence on reading is the same, or nearly so, as when looking at distance.

We operate at once on both eyes: (1.) If the insufficiency when looking at distant objects amounts to about one-third (or more) of that which is found when reading. (2.) If while reading the excluded eye diverges more than 2‴. (3.) If a prism of 6° or more is required for each eye to remedy the insufficiency.

The operation may have the effect of doing away with the necessity of using prismatic glasses for reading, or it may render the eyes fit for improvement by weaker prisms. Diplopia soon disappears, though the operation must be considered more successful if no diplopia exists immediately after it.

INSUFFICIENCY OF THE EXTERNAL RECTI MUSCLES.

This form of insufficiency is observed in myopics who for a considerable time have worn spectacles with the concave lenses too close to each other.

Gradually diplopia appears with a sensation of dizziness when looking at distant objects, and with increased convergence when excluding one eye. These symptoms, not yielding to long-continued treatment by prisms, were in one case permanently and completely removed by division of one of the internal recti muscles.

CHAPTER VI.

THE CORNEA AND SCLEROTIC.

THE CORNEA.

GENERAL AND ANATOMICAL REMARKS.

The cornea, to fulfil its requirements, must possess a normal structure with transparency and a certain curvature.

Its structure comprises the epithelium, the elastic laminæ, and the lamellated tissue or cornea proper.

(*a*) *The Epithelium.*—Upon the anterior surface (of the anterior elastic lamina) of the cornea several layers of epithelial cells occur, whose aggregate thickness amounts to about $\frac{1}{1000}''$. The cells next the elastic lamina are oblong and arranged perpendicularly, those towards the surface are roundish or angular, while the most superficial layer is flattened. On the posterior surface (of the posterior elastic lamina) is found a single layer of polygonal nucleated cells similar to those upon the anterior surface of the iris, and upon the portions of the elastic lamina termed the pillars of the iris.

(*b.*) *The elastic laminæ* are transparent, colourless, elastic, flexible, and homogeneous "membranes" appearing on sections of the cornea, as well-defined transparent lines, which intervene between the epithelium and the lamellated tissue of the cornea. A parallel striated appearance is occasionally observed in them. The elastic laminæ are scarcely altered by acids, or by boiling. If torn off the cornea they curl up in a direction the reverse of that in which they were attached.

Emerging from that surface of the anterior elastic lamina which lies next the lamellated tissue, we observe filaments similar in structure to the lamina, which have a slanting direction and disappear in the thickness of the cornea. The lamina is lost sight of in the texture of the sclerotic. The posterior elastic lamina with its epithelium is one of the boundaries of the

anterior aqueous chamber. The lamina is thinnest at the middle, and thickest at a short distance from the posterior margin of the cornea, just before it splits up into stiff and elastic fibres. The fibres next the cornea are broad, and go to the circular sinus to form part of its walls. The anterior two-thirds of the wall of this canal consist of elastic fibres; the posterior third, the thickest portion, resembles the sclerotic in structure.

The greater number of fibres of the posterior elastic lamina pass on to the ciliary muscle. Those nearest the anterior chamber unite into roundish bundles, which at the margin of this chamber bend over upon the anterior surface of the iris to form its "suspensory ligament" or "pillars."

When using the term *circular sinus*, it must be understood that this sinus is not a canal carrying venous blood, but a plexus of closely packed veins, which freely anastomose with each other, and have a circular course, somewhat parallel with the margin of the cornea. The sinus is imbedded in the sclerotic close to its inner surface; posteriorly it joins the ciliary muscle, anteriorly the fibres which come from the posterior elastic lamina of the cornea.

The bulk of the cornea, situated between the elastic laminæ, is made up of short lamellæ, which are in apposition with each other, and are arranged somewhat parallel with the surface. Between the different lamellæ are placed cells ("corneal corpuscles") which are mononucleated, and anastomose with each other. Immediately beneath the anterior elastic lamina is a close network of *nerve fibres*, with *ganglion cells*, which anastomose with the ciliary nerves. It is stated that the cornea receives most of its nerves, not from the ciliary ganglion, but directly from the fifth nerve.

THE SURFACES OF THE CORNEA.

The anterior surface lies next the eyelids, the posterior next the aqueous chamber. The surfaces are nearly parallel with each other, as appears from measurements of the thickness of the cornea of the healthy middle-aged eye. The thickness of the cornea at the margin is ·05315 in., at the centre ·05393 in., and midway between these ·05472 in.

Before entering into a description of anomalies of the cornea, an explanation of some of the terms employed is necessary.

The cornea with reference to *the curvature of its anterior surface* may be described as the top segment of an ellipsoid.

To make clear the terms employed in connection with such a figure, take the shell of a hen's egg, which in section resembles an ellipsoid, and through the egg draw three axes, one long, and two short.

The long axis, if extended, is supposed to pass through the middle of the pointed end (the apex) of the egg. This part, cut off, represents the top segment of an ellipsoid.

The two short axes pass through its sides; and if we assume two opposite sides of the egg to be somewhat flattened, the axis, perpendicular to the flattened sides, will be shorter than the one at right angles to it. Lines drawn upon the surface of the eggshell, and carried through the points where the long and either of the short axes touch the shell, are termed meridians.

In the description of the curvature, apex, &c., of the cornea, we make use of the above terms. We speak of an apex, of meridians, of a long, and of two short axes of this top-segment.

The apex of the cornea corresponds to the centre of its anterior surface; while the curvature of the cornea is asymmetrical; that is, its convexity varies in different directions. This variation, as regards both eyes of the same person, is, however, very slight. The convexity, as a rule, is greatest from above downwards, i. e. in a vertical direction (or in its vertical meridian), while it is least from side to side, i. e. in a horizontal direction (or in its horizontal meridian).

The shortest radius of curvature therefore corresponds to the vertical, the longest radius of curvature to the horizontal, meridian of the cornea, the section being carried through the long and one of the short axes.

The length of the radius of the cornea at its apex is ·31496 in. One of the short axes, has, as a rule, a horizontal, the other a vertical direction, or nearly so. (See also The Eyeball considered as an Optical Instrument).

We further distinguish in the cornea a margin, or periphery, i. e. the part which joins the sclerotic; or to speak more precisely, an anterior margin (the one next the eyelids), and a posterior margin (the one next the aqueous chamber).

The posterior margin is not of equal size with the anterior, but has a somewhat larger diameter.

These margins are tolerably well defined.

EXAMINATION.

The cornea, though appearing transparent and of normal shape to the naked eye, may present anomalies of curvature and opacities, which can only be recognized by artificial means.

The presence of opacities is best ascertained by *lateral illumination.* The patient, seated in a dark room by the side of the steady flame of a lamp, is directed to look straightforwards, while the observer, by means of a strong convex lens, concentrates the light upon the surface of the cornea, and in succession illuminates the different portions. This mode of examination is superior to any for the recognition of anomalies of transparency.

Anomalies of curvature are ascertained by examination with the ophthalmoscope or with the ophthalmometer.

Examination with the ophthalmoscope.—The inverted image of the optic

disc of the eye, the curvature of the cornea of which we wish to examine, is brought into view in the usual way. Then by moving either the convex lens or our own head (continually keeping in view the optic disc), we cause the rays, which come from the disc and from the vessels in it, to pass through a different part of the patient's cornea each time we shift the head or the lens. The outlines of the disc and of the vessels appear distorted, interrupted, &c., if seen through portions of a cornea the curvature of which is disturbed.

Those who can "feel" the alterations in the tension of their ciliary muscles, when the vessels in the optic disc are examined with the ophthalmoscope "directly," can recognize differences in the curvature of the cornea, by the increase or relaxation of the accommodation which is necessary to render distinct the outlines of the vessels which run horizontally or vertically.

The ophthalmoscopic inspection is, for practical purposes, a good means of recognizing anomalies of curvature. The degree and the variations of curvature can however with accuracy be ascertained only with the ophthalmometer, a mathematical instrument, the explanation of which does not fall within the limits of this book.

The sensibility of the cornea is ascertained by touching the different points of its surface with a soft piece of paper.

To inspect the cornea in children who suffer from intolerance of light, assistance is required to keep the body, hands, &c., well steadied. Having grasped the child's head between our knees, we open the lids with the fingers (which requires much practice), or more easily, by inserting a strong wire speculum. The eyeball, to bring the cornea into view, may have to be fixed and moved in various directions with forceps.

DEVELOPMENT.

The curvature of the fœtal cornea at first appears the same as that of the sclerotic. During development of the iris, and at about the sixth month it is somewhat conical; at about the ninth month it appears normal.

The cornea at the end of the fifth month is small and thick compared with the sclerotic. Microscopically, it consists of nucleated fibres; some of the nuclei being oval, others round, giving the fibres an undulating appearance.

Where its inner surface joins the sclerotic, a projecting rim is observed for the insertion of the ciliary muscle. At the time when the iris makes its appearance the cornea is oval in shape, the horizontal diameter being shorter than the vertical.

Soon after the cornea can be recognized as such it undergoes a change in transparency; and again about the fourth month. At the latter period numerous blood-vessels are observed encroaching from the outer and inner

surfaces of the sclerotic upon the corresponding surfaces of the cornea; they occupy about two-thirds of the latter, but do not quite reach the middle. The vessels at the inner margin anastomose with those of the choroid and ciliary muscle. Soon after the blood-vessels the elastic laminæ appear.

The circular sinus is perceptible about the middle of the fifth month.

Senile changes.—The cornea, as age advances, becomes somewhat more convex and slightly altered in thickness. Its transparency, except in case of *arcus senilis,* suffers less than that of the other media.

The arcus senilis may appear as early as the age of thirty. It is grey, greyish white or chalky white, and opaque or semiopaque, and is situated in the cornea, about $\frac{1}{10}''$ from its margin, a narrow rim of transparent cornea intervening between it and the sclerotic. It shades off towards the centre, but is more sharply defined towards the margin of the cornea. It appears first along the upper and lower margins, sometimes forming ultimately a complete opaque ring broadest above and below, the enclosed transparent part of the cornea having a somewhat oval shape.

On minute examination it is found most marked close beneath the anterior elastic lamina. Here the lamellated tissue is brittle, and the cells among the lamellæ are loaded with minute granules (fat molecules?).

The elastic laminæ, as age advances, become brittle and fissured; they lose their flexibility and increase in thickness. Warty pedunculated or flat elevations of the substance of the laminæ appear, especially along the margin of the cornea, sometimes as early as the age of thirty.

CONGENITAL ANOMALIES.

The cornea, about the third month of fœtal life, is opaque, and has a curvature similar to that of the sclerotic. This condition, complicated with microphthalmos, has been observed at birth in otherwise fully developed children. Cases, in which the cornea was conical or globular, have occurred occasionally, with a conical shape of the head. Increased thickness of the conical portion was observed in a few cases; but in most a thinning of the cone, in some with thinning of the rest of the cornea.

A marked difference in the curvature of the cornea in its vertical and horizontal meridians is frequently observed.

Staphylomata, occupying the place of part, or of the entire cornea, are attributed to suppuration of the cornea before birth.

As anomalies of transparency there have been observed opacities either occupying the entire thickness, or only the surface, or the marginal parts of the cornea (the centre alone remaining transparent); or a crescentic or circular opacity, termed *arcus fœtalis,* differing from the arcus senilis, by being continuous with the sclerotic. A double arcus fœtalis (one within the other) has occurred. This arcus, like other congenital opacities, may disappear spontaneously.

In cases of coloboma and of microphthalmos we sometimes observe roundish opacities at the inner and outer margins of the cornea of both eyes.

Too large or too small corneæ are usually found associated with congenital anomalies of the eyeball.

Corneæ, the contours of which resemble the figure 8, placed horizontally, or double corneæ, have occurred in cyclopic eyes.

INJURIES.

Foreign bodies.—Particles of iron, insects' wings, &c., lodged in the cornea, if they cause pain or inflammation, or otherwise impair vision, must be removed. Pieces of glass, grains of gunpowder, &c., may remain in the cornea for years without causing disturbance.

We first try, with a soft piece of linen or blotting-paper, to wipe the foreign body from the surface of the cornea.

If we do not succeed in this, *we steady the eyeball* thoroughly in the following manner:—Standing behind the patient, who is seated and rests his head against our chest, we raise the upper lid with the first finger of one hand, and having directed the patient to "look down," place the tip of the same finger upon the sclerotic, just above the cornea. We then depress the lower lid with the tip of the middle finger of the same hand, and at the same time place it upon the eyeball near the inner and lower margin of the cornea. By pressure upon the eyeball with the two fingers we can thus completely control its movements. A spud (or the point of a penknife) is used to lift the foreign body from the cornea. Any stain should be scraped away at the same time.

Care should be taken to limit our operations to the spot occupied by the foreign body.

If the foreign body be fixed deeply in the substance of the cornea, a fine forceps may be necessary for its extraction. If there be danger of its falling into the anterior chamber, an incision must be made through the cornea into that chamber, at some distance from the foreign body, and a spatula introduced and carried behind to support it, and thus prevent its falling back; after which it may be removed with a spud or sharp needle or with the forceps. Sometimes it is necessary to cut down upon the foreign body directly through the cornea. No further treatment is required, if the body has been removed without scraping the cornea, and if the cornea is otherwise clear; except that the eyelids should be kept closed with some wet lint, and a bandage applied, until all irritation has disappeared.

Prolapse of the iris, even if some of the substance of the cornea is lost, may be avoided by the use of calabar.

Perforating wounds of the cornea.—The edges of a clean cut may

adapt themselves at once, so that the relations between the cornea, the aqueous chambers, and the iris are not disturbed. In other cases most of the aqueous humour escapes, the iris comes in contact with the cornea, and some fluid oozes from the wound, when the eye is pressed upon.

A foreign body may pass into the eye and wound the iris, lens, &c., and the wound in the cornea be overlooked. In cases in which, from the account given by the patient, or from the nature of the injury, we entertain doubts as to the presence of any extraneous substance in the eye, we should carefully inquire into the nature of the injury, whether the instrument with which it was inflicted was clean, whether the patient saw the foreign body (e. g. the piece of metal which struck the eye) removed, or whether he supposes it to be still in the eye. We must be guarded in our opinion, especially if there be cataract, which may have been caused either by the concussion alone, or by a foreign body having passed into or through the lens. The smallest foreign body lodged in the choroid generally gives rise, within a few days after the injury, to ophthalmitis. Atrophy and gradual shrinking of the eye follows. Foreign bodies, especially portions of copper, lead, small shot or glass, have remained in other parts of the eyeball for years, impairing its function but slightly.

If with the ophthalmoscope, and by examination with lateral illumination, we have been able to satisfy ourselves that there is no foreign substance within the eye, our prognosis depends upon the number of parts injured. (See injuries of Iris, Lens, Choroid, Retina, &c.)

Perforating wounds of the cornea, if the cut surfaces are clean, heal readily; thus the large incision made for the extraction of cataract may be found united after 24 hours.

On minute examination, a few hours after an incision has been made through the cornea, we find nuclei in and round the wound, giving the adjoining cornea a slightly opaque appearance. Out of these the tissue becomes developed, which, blending with the cornea, unites the surfaces of the incision.

Treatment.—The wound should be cleaned by allowing a gentle stream of tepid water to pass over the cornea, care being taken not to press upon the eye. Particles of foreign substances, or portions of iris, of vitreous, &c., projecting from the wound, must carefully be removed with the iris forceps and iris scissors. To do this, the patient should be brought thoroughly under the influence of chloroform if straining or if the manipulations in cleaning the wound are likely to cause escape of vitreous substance, prolapse of iris, or injury to the lens.

Calabar is applied, if contraction of the pupil is likely to prevent prolapse, or adhesions of the iris, e. g. if the wound is near the margin of the cornea; while atropia is used if the wound is near the centre of the cornea. Complete rest of the eye by means of a firm but lightly-pressing bandage,

and the application of atropia to the non-injured eye, should be prescribed until the state of the anterior chamber, and the absence of all irritation, indicate complete union of the wound.

Concussion of the cornea, with or without abrasion of its surface, is not unfrequently followed by severe corneitis, sometimes amounting to suppuration with hypopion, iritis, or even ophthalmitis. We must therefore, however slight an injury with concussion may at first appear, be guarded as regards our prognosis.

Atropia, rest, tepid lotions, tonics, and other means employed in the treatment of corneitis with suppuration are made use of.

Abrasions of the epithelium of the cornea, e. g. by a scratch with the finger nail, are extremely painful. The pain is best relieved by placing some clean fresh olive oil upon the cornea, and keeping the injured, or (if complete rest be required) both eyes closed for one or several days. The eye often remains irritable and painful for a long time after the abrasion has healed.

Burns with unslaked lime, &c. Necrosis of the cornea may be expected, if a few hours after the injury it becomes white and opaque, or if its surface becomes hard.

After from two to five days suppuration sets in round the necrosed part, and the latter is finally eliminated. In young persons it has repeatedly occurred that the cornea has not sloughed although it has appeared milky and opaque throughout immediately after the burn, or it has sloughed only superficially, and has again become almost transparent after one or two years. The surface of the conjunctiva and cornea must be cleaned with tepid water, prominent or loose particles of sloughing or burnt tissue removed with scissors, and a slight pressure bandage applied over the closed eyelids. (See Injuries of the Conjunctiva.)

TUMOURS.

Prolapse of the iris, lymph in the cornea, staphylomata (transparent or opaque), have been mistaken for tumours of the cornea. Small polypi have been observed at the margin of the cornea.

A preparation in the Museum of the Eye Infirmary, Moorfields, shows a cancerous (partly medullary, partly melanotic) tumour seated in part upon the outer surface of the cornea, in part upon the sclerotic, the rest of the eye appearing healthy.

The so called *dermoid tumour* is congenital, occurs frequently, is oval in shape, or rounded, varies in size (being sometimes as large as a bean); is white, rarely brown, with a flat base situated partly upon the cornea, partly upon the sclerotic. It may occur symmetrically in both eyes, or in one eye only, and generally at the outer and lower margin of the cornea.

In few cases two dermoid tumours have been observed in each eye (one at the outer and one at the inner margin of the cornea). Pale or dark well-developed hairs are frequently seen projecting from the generally smooth surface. The tumour may be either soft or of cartilaginous hardness, and slightly moveable. It increases in size during the general growth of the body.

If removed, a slight opacity remains, though the cornea may seem transparent immediately after the operation. Sufficient should be removed to bring the surface level with the curvature of the cornea. Removing it too near the eyeball has been followed by severe inflammation.

Previous to the operation chloroform is administered. The eyelids being kept open by the wire speculum, the tumour is firmly seized with forceps, and the point of a cataract knife (the flat part resting on the eyeball, the cutting edge directed towards the cornea), is thrust through its base, where this joins the margin of the cornea.

The blade is then pushed on between the tumour and the eyeball, following the direction of the margin of the cornea. The portion attached to the surface of the cornea is separated first, and finally that attached to the sclerotic.

The lids, after the operation, are kept closed; and lint dipped into ice-cold water is applied frequently.

Minute examination of the tumour shows it to be situated beneath the conjunctiva, and to be covered by a thick layer of epithelial cells. In it are found hair follicles surrounded by numerous blood-vessels, sebaceous glands, nerve fibres, fat cells, and a mixture of elastic and connective tissue fibres.

In the part nearest the cornea cartilage cells are occasionally met with.

CORNEITIS (KERATITIS; INFLAMMATION OF THE CORNEA).

Syphilitic Corneitis (*Scrophulous, strumous Corneitis; Strumous Ophthalmia; Aquo-capsulitis; Corneitis punctata*).

This form of corneitis rarely occurs in infants or in very young children, or in persons advanced in age; but most frequently between the ages of nine and fifteen; and in girls oftener than boys. It appears, as a rule, in connection with syphilitic changes in other parts, and is the result of inherited syphilis. On inquiry, we often find that the mother of the patient had miscarriages or still-born children previous to the birth of the one suffering from corneitis; also that the patient has suffered from other symptoms of syphilis during infancy, as prolonged snuffles, a sore mouth, ulcers round the anus, various skin eruptions, &c.

Hydrocephalus of different degrees, discharge from the ears, and deafness, are common complications.

The physiognomy of these patients is very characteristic, and when once recognized cannot readily be overlooked. Its peculiarities are—a generally old, pale-looking face, a squarish forehead, with the bridge of the nose frequently wide and depressed, which, in most cases, is the result of anomalous development of these parts; in a few, the effect of loss of bone from caries. Cicatrices of former fissures in the skin round the lips, especially about the angles of the mouth, are met with, and there is a peculiarity in the shape, size, colour, and number of the permanent incisor teeth, especially of the upper central ones. These teeth are small, narrow, squared, sometimes of a yellowish colour, and as a rule more or less deeply notched in a vertical direction. (See Plate III. figs. 4, 5.)

The corneitis generally appears in both eyes, though seldom simultaneously; a few days or weeks (rarely more than a year) pass, before the fellow eye is attacked. The left eye frequently suffers first. Recurrent attacks, though rare, have been observed in both eyes, sometimes repeatedly. The corneitis may take a chronic cause, and continue for several years; the cornea may become completely opaque or crimson red, yet again recover its transparency after a few weeks.

Vision.—Patients generally seek advice on account of the impairment of sight.

Vision for a time may be reduced to mere perception of light, from the corneal changes alone. It frequently remains permanently impaired through changes in the other tunics. The degree of impairment varies during the different stages of the inflammation. The patient, if able to read, holds the type very close. Vision may remain permanently impaired from one or several of the following causes:—Opacities in the cornea, alterations of its curvature, opacities in the crystalline lens, changes following choroido-retinitis, inflammation of the optic nerve, or cerebral changes, as hydrocephalus, &c. The ocular changes, though varying in degree, occur as a rule in both eyes, but are often more severe in the left. Vision may remain useful during the prime of life, but fail prematurely.

Patients are often much distressed by the diffusion (dazzling) of light, caused by its transmission through semitransparent portions of the cornea.

A profuse flow of tears, intolerance of light, slight swelling or spasmodic closure of the lids, are sometimes present, but may be entirely absent, or may appear or disappear during different stages of the corneitis. They are usually caused by changes on the surface of the cornea, e. g. vesicular or nodular elevations.

As a rule there is no pain or hardly any complained of in the eye while there is sclerotic or conjunctival redness. Sometimes, however, very severe pain occurs during the process of cicatrization, if the ciliary region has been implicated, or if choroiditis round the optic disc has accompanied the corneitis.

The vascularity of the ocular conjunctiva is in many cases but slightly increased, while a more or less broad pink zone in the sclerotic, along the margin of the cornea, is usually present.

Course.—The cornea at first loses its transparency more or less, especially in the centre and lower half. Frequently small, ill-defined, grey, yellowish or brownish, and opaque dots, in groups or singly, appear in its lamellated structure; more frequently at or near the posterior elastic lamina, about the middle or lower part. This appearance, if combined with slight iritis, is described by some as "*Aquocapsulitis.*" It may be absent, or the patient may present himself after it has passed away. The surface of the cornea often appears dull, or slightly uneven, as if pricked with a pin in numerous places.

In rare cases small flaccid vesicles or pustules appear upon it, usually along its upper margin. These are situated immediately beneath the anterior elastic lamina.

Within a few weeks the entire cornea may have lost its transparency, assuming a ground-glass colour, some portions (the most depending) being more densely opaque, or appearing pink or crimson. The red colour is most intense at the surface and periphery of the cornea, and is caused by blood-vessels passing from the substance of the sclerotic between the lamellæ of the cornea. These vessels are placed close together, and run somewhat parallel.

In severe attacks, or in patients of feeble health, lymph is abundantly developed in the cornea and iris, the former assuming a yellow and opaque colour.

Swelling of the iris and cornea, and their adhesion to each other, are followed by dense and permanent opacities occupying most frequently the lower half of the cornea.

The cornea rarely regains its transparency throughout; changes in its curvature and faint opacities remain for life, particularly if the ciliary processes have been much implicated.

Though the cornea be the part most conspicuously altered, we find as a rule the other tunics simultaneously inflamed. The surface of the iris, after the corneitis has subsided, presents in most cases a characteristic and permanent steel-grey hue. Posterior synechiæ or irregularities of the pupil often become visible after instillation of atropia. With the ophthalmoscope we frequently discover changes in the transparency of the lens; its nucleus becomes prematurely large, yellowish, and strongly light-reflecting. Dotted opacities occur on its surface beneath the capsule.

Changes in the vitreous chamber, with or without opaque shreds floating and gravitating in it; chronic suppuration of the choroid and vitreous substance, with subsequent softening and shrinking of the eye,

and consequent loss of sight, are not unfrequent occurrences. These lesions have been observed in both eyes of the same patient. (See also Syphilitic Changes in the deeper parts of the Eye.)

Treatment.—The general treatment, as long as active inflammation (deep seated or superficial) is going on, is directed against the syphilitic diathesis. Frictions with mercurial ointment are employed. Ungt. Hydrarg. Nitratis Mitius, "the size of a small pea," is ordered to be rubbed over the eyebrows at bed-time, and the internal use of Iodide of Potassium with Sarsaparilla are prescribed. Some patients, however, are so weak, that good nourishment is the only thing that should be ordered for some time. In such cases the formation of pus or lymph is particularly abundant.

Locally, we use atropia, a few drops to be applied to the conjunctiva of the lower lid with a camel's hair brush, from three to six times daily, as long as the tunics are unduly vascular; and three times weekly for one or two months after all vascularity has subsided.

Slight purulent or catarrhal ophthalmia seems to hasten the course of the corneitis considerably, and the application of warm fomentations over the closed lids, every quarter of an hour during the day, and a linseed-meal poultice at night, should be tried in all cases as long as the cornea appears vascular. These local means also favour the rapid development of blood-vessels in a cornea in which the lymph tends to change into pus, and thus prevent perforation, &c. Some advise for the same purpose the local application of the Oleum Terebinthinæ.

The often occurring intolerance of light with spasmodic closure of the lids, if it do not in a few weeks yield to the application of atropia, may be speedily removed by the insertion of a seton into the adjacent temple.

Slight pressure, by means of lint and cotton wool tied over the closed lids, materially assists in the preservation of the natural curvature of the cornea, and of the shape of the eyeball; and should be kept up until all undue vascularity has subsided.

Opacities of the cornea occur frequently after all inflammation has ceased in spite of appropriate treatment. (For treatment see Opacities.)

Changes in the deeper structures of the eye not unfrequently give rise to anomalies of shape and refraction, and complicate those occasioned by the cornea alone.

The patients are not benefited by iridectomy, nor by operation for artificial pupil, as long as active inflammation is going on. They need neither be kept in a dark room, nor be prohibited from using their eyes as much as they can, unless a bandage be thought necessary to preserve the curvature of the tunics. We must insist that the patients do not stoop, when looking at small objects, books, &c., also that they hold these at the distance

of from twelve to twenty inches from the eyes, and that they do not occupy themselves with objects which require to be brought nearer.

If these rules be attended to, alterations of the curvature of the tunics of the eyeball, and permanent impairment of vision, are less likely to occur.

The patients, or the parents, must be informed of the often very slow course of the disease, which may extend over months; and of the frequently permanent impairment of vision with opacities of the cornea, &c., which often ensue.

Strumous Corneitis (*Vascular Corneitis; Strumous or Scrophulous Ophthalmia*).

This form of corneitis has been observed at all ages, but most commonly in scrophulous children, and in females shortly before, or about, the age of puberty.

Injuries of different kinds, foreign bodies upon the cornea, inverted eyelashes, also pustular ophthalmia, may in weakly persons give rise to it.

Vascular corneitis accompanies the different forms of suppuration of the cornea (in which cases its appearance is a favourable symptom); it is also present during the healing of ulcerations.

The absence of nodular infiltrations distinguishes it from pustular corneitis.

The patient suffers from pain "in the inflamed eye;" this sometimes is severe, and extends over the corresponding side of the head and face.

The lids are generally red along the margins, slightly swollen, and spasmodically closed, and there is abundant flow of tears, with more or less intolerance of light. These symptoms, coupled with the presence of one or several small ill-defined opacities in the cornea, are characteristic, provided there be no changes in the conjunctiva, as granulations, which may give rise to similar symptoms.

Opaque and slightly vascular (inflamed) spots appear in many cases, at the onset of the attack, at or near the centre of the cornea; in some these spots seem to advance from the margin towards the centre. They are superficial; they rarely extend into the deeper parts. In weak persons the entire thickness of the cornea may be implicated.

The inflamed portions, which appear grey, greyish white, or yellowish and opaque, shade off into the transparent cornea, or merge into the sclerotic. The vascularity of the sclerotic and conjunctiva is most marked next the inflamed part; a varying number of vessels pass towards or into the opacity.

Ulceration or suppuration of the inflamed portion, with perforation

and hypopion, or iritis, may occur if the patient be weak, or the corneitis wrongly treated.

The cessation of intolerance of light, and of the flow of tears, are sure signs of improvement. The blood-vessels and the redness and swelling of the lids then gradually disappear, the opacities fade away, and the cornea becomes again transparent. Semi-transparent opacities disappear in from three to nine months, but dense white or grey opacities may remain for life.

A peculiar form of vascular corneitis, accompanied by pain, intolerance of light, and lachrymation, is sometimes observed, more particularly in young females. Its symptoms are—a dense vascular web, resembling pannus, and generally appearing first like the latter along the upper margin of the cornea, but distinguished from it by the absence of "granulations in the conjunctiva." This form is probably of syphilitic origin. It readily subsides after the insertion of a seton into the temple; small doses of bichloride of mercury being at the same time prescribed.

Treatment.

The intolerance of light and the spasmodic closure of the eyelids are the most troublesome symptoms of strumous corneitis. The former is caused by uneven and opaque portions of cornea; the latter is a reflex action, but may lead to a spasmodic condition of the orbicularis muscles which persists after the changes in the cornea have subsided.

The insertion of a seton into the skin of the corresponding temple hardly ever fails to remove the intolerance of light. The application of the Tincture of Iodine to the skin of the eyelids twice a week should be used, if the seton be objected to. Excision of a small portion of the supra-orbital nerve, or division of the nerve, where it passes round the margin of the orbit, has been recommended by some.

In adults, if there be much pain or "redness" a few leeches to the temple may be tried. The pain and intolerance of light may also be relieved by frequently fomenting the eyelids with lint dipped into warm water, and by the application of olive oil containing some chloroform or morphia, to the skin round the eyes.

In all cases we order a few drops of atropia to be applied to the conjunctiva once daily, and the eyelids to be bathed occasionally with warm poppy-head lotion. The inflamed eye, or the one which is more inflamed if both are affected, is kept bound up until all redness has subsided.

If there is any purulent discharge, with or without an eczematous condition of the skin at or near the margins of the eyelids, or if the latter stick together after sleep, the patient is ordered to bathe the eczematous parts twice daily with alum lotion, and after having dried them well, to rub in some of the Unguent. Hydrarg. Nitrat. Mitius.

The ointment should be washed off with warm water, and alum lotion used before applying fresh ointment. This, if repeated morning and night, succeeds in removing the eczema in from three to ten days as a rule, and thus gets rid of a great source of irritation.

In making use of medical treatment we must be guided by the state of the patient's general health. Plain diet and cleanliness are essential. Children or adults, with a swollen or eczematous condition of the nostrils, are much benefited by the internal use of arsenic combined with steel.

The fact that the insertion of a seton alone removes, within the shortest time, the troublesome symptoms of most cases of vascular corneitis, provided the cause (granulations, cicatrices, &c.) be not seated in the conjunctiva of the lids, must not be lost sight of when considering the effects of internal remedies.

If ulceration or suppuration of the cornea complicate the case, we must be guarded in our prognosis, and the patient or the parents should be informed that a "speck" will remain on the eye for a long time, perhaps for life. (See treatment of Suppuration, Ulceration, and of Opacities of Cornea.)

PUSTULAR CORNEITIS (*Phlyctænular, Strumous Corneitis; Herpes Corneæ; Pustular or Strumous Ophthalmia*).

Pustular Corneitis, like the foregoing form, occurs most frequently in young persons and children.

Extreme intolerance of light, continuing sometimes for months, slight redness, swelling and spasmodic closure of the eyelids, an abundant flow of tears, and frequently eczema of the surrounding skin, often with comparatively but slight changes in the cornea, are the usual symptoms.

As the pathognomonic sign we observe one or several roundish, small, somewhat projecting opaque nodules in the superficial layers of the cornea, standing alone or in groups, or in a row at or near the margin of the cornea. One nodule or a small group of nodules may appear at the apex of a bundle of blood-vessels, which latter diverge over the cornea, forming a vascular triangle, and ultimately lose themselves in the adjoining conjunctiva.

The nodules often appear in the conjunctiva first (Pustular Ophthalmia), or are preceded by attacks of ophthalmia with sclerotic vascularity and intolerance of light. Nodules, pustules, patches of vascular corneitis, small ulcerations, and opacities may be found together. In rare cases the entire surface of the cornea and conjunctiva is covered with vascular cicatrices, intermingled with pustules and nodules in different stages of development. At an early stage we may find the corneal epithelium raised at the apex of the nodule, causing a resemblance to a pustule.

The nodule, or part of it, may either undergo suppuration sometimes

in a few hours, or change into an ulcer, which by its extension may lead to perforation of the cornea. The changes of the nodules are preceded and accompanied by the above-mentioned symptoms, by inflammation of the surrounding cornea, and by a varying amount of vascularity of the sclerotic and conjunctiva.

The duration of these cases varies much. Some patients recover in a week, others only after months. The number of successive nodules, the time required for repair of the lesions of the cornea, the complications with higher degrees of corneitis, and in a few cases with iritis, are some of the causes of its prolonged duration. The cessation of intolerance of light is always a sign of a favourable turn of the disease.

The corneitis may return for several years at about the same season, or at any time when the general health is impaired.

Whether the affected portion of the cornea ultimately become transparent, or remain more or less opaque, depends upon the size, changes, and number of the nodules.

One or several dull or chalky white and opaque spots, shading off into the surrounding cornea, sometimes of the peculiar triangular shape mentioned above, may permanently remain.

Causes.—Pustular corneitis is most common in what are termed strumous persons. It frequently occurs after scarlatina, measles, and variola. It is most obstinate in persons suffering from acne rosacea, and from herpes of the mucous membrane of the nose. It is attributed by some to deranged function of the fifth nerve.

Treatment.—The general medical treatment varies according to the state of health. In children particularly we order plain regular diet with some wine, and a warm bath every day. If the lips and nostrils are swollen and red, with crusts round the nasal orifices, preparations of arsenic with iron will be found of great use. If the sclerotic is implicated (much swollen and vascular), the bichloride of mercury is prescribed. In adults the dose is one-sixteenth of a grain in half an ounce of water, twice daily.

In young children the exhibition of the Hydrarg. c. Cretâ will be found of use at the commencement.

The general medical treatment is continued for two or three weeks after all intolerance of light has subsided.

Local treatment.—Adults must wear a shade or blue spectacles, while at the same time the more inflamed eye is kept bound up. In children, both eyes, if severely inflamed, must be kept closed for one or two weeks. Touching the vesicle at the apex of the nodule with the solid nitrate of silver may arrest the inflammation at once; but we rarely see the case at this early stage. If the vascularity, pain, and sensation of heat are great, one or two leeches should in grown persons be applied, at bed-time, to the corresponding temple.

In all cases we prescribe atropia, to be applied once daily, with a camel's-hair brush, to the conjunctiva of the lower lid of the inflamed eye.

The intolerance of light, if the lids cannot be kept bound up, is relieved by the application of the tincture of iodine, twice a week, to the skin of the lids. The insertion of a seton into the skin of the temple removes sooner than any other remedy the most obstinate spasmodic closure of the eyelids and intolerance of light, without any other treatment being required. Cases treated by the seton appear less liable to relapse. If the vascularity of the conjunctiva or cornea is considerable, but the intolerance of light and the flow of tears moderate or absent, calomel powder, applied twice daily to the cornea, until all vascularity has disappeared, has been found of use.

Lotio Aluminis is ordered, to wash the margin of the eyelids carefully, morning and night, if they are at all gummed up. The lotion is discontinued as soon as this has subsided. If the discharge is only watery, we order the lids to be kept clean with warm water, or with Lotio Papaveris.

The skin of the lids, if excoriated, should be washed twice daily with warm water or warm Lotio Aluminis, well dried, and then some of the Unguentum Hydrargyri Nitratis Mitius should be rubbed upon the excoriated portion. The eyes should not be used for near work as long as there is increased vascularity, with intolerance of light; and the patient must be informed of the liability to fresh attacks. (For further treatment, see Opacities of the Cornea.)

Insertion of a Seton into the Temple.

The patient is seated, with his head well steadied against the surgeon's chest, who stands behind him. The surgeon, to avoid wounding the temporal artery, first ascertains its pulsation beneath the skin. He then pinches up a fold of skin between the outer margin of the orbit and the artery, and thrusts the seton-needle, armed with stout silk thread, through the entire thickness of the skin, on the side of the fold next the ear, pushes it on in a vertical direction beneath the skin, along the base of the fold, and brings it out about an inch and a half higher up. The silk thread (seton) thus lies close in front of, and somewhat parallel with, the temporal artery. The needle is removed, and the silk securely tied into a loose loop, to allow of its being moved to and fro. The hair being placed over it, hides it from view.

Bleeding beneath the skin sometimes occurs, causing considerable swelling, if the temporal artery has been wounded. The seton should be removed at once, to arrest undue loss of blood, if the escape of blood is profuse and of arterial character, or if it does not discontinue within half

an hour. Another seton may at once be placed into a part of the skin beneath which the hæmorrhage has not extended.

The patient or nurse must be shown how to move the seton to and fro: this should be done once daily.

The seton gives rise to inflammation of the surrounding skin, and purulent discharge, which latter should be carefully cleansed away with warm water twice daily.

The discharge may cease before the seton has had the desired effect, if the tract through which the silk passes becomes cuticular.

Insertion of a seton into another part of the skin, or application of some irritating ointment to the first one, should be tried.

Large granulations or much swelling of the skin need not alarm us. The seton may be removed after the intolerance of light and corneitis have subsided. A new one must be introduced (through the original tract, if possible) if the first should fall out accidentally. The openings in the skin, after removal of the seton, gradually approach each other, and frequently coalesce leaving a hardly perceptible cicatrix.

The seton is of the greatest use in opacities, pustules, and ulcers of the cornea, when accompanied by spasmodic closure of the eyelids, increased vascularity, lachrymation, and intolerance of light, where granulations of the conjunctiva are not present simultaneously.

It may be inserted at any age, and is, in hospital practice, almost the sole remedy adopted for the rapid removal of the disturbances accompanying the just-mentioned corneal changes.

Pannus (*Vascular cornea*).

Pannus is a term applied to a vascular condition of the surface of the cornea. Pannus appears, as a rule, first along the upper margin of the cornea, where blood-vessels encroach upon its surface from the surrounding conjunctiva and subconjunctival tissue.

Pannus often accompanies morbid changes of the conjunctiva of the eyelids, especially granular ophthalmia.

Attacks of corneitis, of ulceration, suppuration, softening, &c., of the cornea, may appear as complications of the pannus.

The term *Xerophthalmos* is applied to the species of pannus in which a dry, grey, and opaque cuticle, continuous with the conjunctiva, covers the surface of the cornea.

Treatment.—For treatment of pannus with granulations in the conjunctiva, see Granular Ophthalmia.

Pannus caused by contraction or distortion of the tarsi, with contraction of the palpebral aperture, often disappears after enlargement of that aperture by operation.

Pannus caused by cicatrices in the tarsus, is much relieved by the excision of a portion of tarsus, which includes the cicatrix.

If the cause of pannus is removed, and the latter slight, occupying, for example, only the upper third of the cornea, no further remedies need be applied; but if it is considerable, so as to hide the pupil from view, and if there is no pain or increased heat, or undue watering of the eye, benefit is derived from the application of a solution of nitrate of silver (gr. x. ad aquæ ℥i.) with a camel's-hair brush, to the surface of the pannus every other day; and by touching any granulations, which may be present in the pannus, with solid nitrate of silver.

The operation of syndectomy is recommended by some, and by others the treatment by inoculation.

Corneitis with Suppuration (*Abscess in the Cornea; Suppuration of the Cornea*).

A yellowish-white, or yellow and opaque, discoloration of the cornea, when it appears in the course of corneitis, or of ulcers of the cornea, generally, indicates the presence of pus.

The pus may accumulate between the lamellæ of the cornea, layers of pus alternating with lamellæ, and thus no pus may escape, when the suppurating cornea is punctured.

The lamellæ frequently however become destroyed, and an *abscess* with irregular lamellated walls is found. The weight of the pus, the pressure of the aqueous humour, and the distance of the pus from the surface of the cornea, modify the shape and size of the abscess. The abscess rarely remains stationary for longer than a week, but perforation into the anterior chamber may occur, giving rise to hypopion, to iritis, &c.; or perforation outwards may be followed by ulceration, by escape of aqueous humour, with anterior synechiæ, or lastly, by opaque or staphylomatous cicatrices. The extent and situation of the opacity, which mostly follows, depend upon whether the suppuration has been confined to the centre or to the margin, or whether the entire cornea has been affected.

Onyx signifies an accumulation of pus between the lamellæ of the cornea, the pus having gravitated in the inflamed portion, so as to assume a yellow and opaque crescentic figure, near the margin of the cornea.

The onyx may remain stationary for several weeks, and not seldom occurs in connection with *hypopion*, i. e. with an accumulation of pus, of shreds of corneal tissue, &c., at the most depending part of the anterior chamber.

Hypopion frequently accompanies those large, flat ulcers which follow an injury, such as an abrasion of the surface of the cornea, in debilitated subjects.

The pus and fibrin are supposed to reach the anterior chamber by transudation from the cornea. They may finally become absorbed or escape by perforation of the cornea. Onyx or hypopion may be complicated with an abscess in the iris. The pus, whether in the iris or in the anterior chamber, changes its position during certain movements of the eye.

The inflamed and suppurating parts of the cornea may become rapidly destroyed ; the cornea being changed into a grey, semitransparent, pulpy, or flaccid, pale yellow substance, which is sometimes thrown off by the pressure of the aqueous humour. Extensive suppuration may however subside, and leave the cornea transparent, or nearly so, if the pus is thick and the intervening lamellæ of the cornea not destroyed.

Practically, we may distinguish—

(*a.*) Cases in which the suppuration comes on rapidly, in from one to three days, with great increase of vascularity and pain, with some chemosis, intolerance of light, and lachrymation. This form often follows operations or injuries, especially blows from stones, from branches of trees, &c., accompanied by abrasion of the cornea. It may also appear in the course of pustular corneitis and purulent ophthalmia.

(*b.*) Cases in which the suppuration appears slowly, and has been preceded by protracted corneitis, as in weak, ill-fed persons, suffering from syphilis.

(*c.*) Cases where there is no intolerance of light or hardly any, with chemosis, mostly serous, with moderate, watery, or purulent discharge, and with rapid suppuration. This form is observed spontaneously, or after operations on very old or decrepit persons, and after severe illness, fever, &c.

Suppuration, confined to the centre of the cornea and occupying often its entire thickness, has been observed in children as an epidemic. In such instances it has increased rapidly with ulceration, while the cornea adjoining the suppurating part has appeared hardly changed. This in severe cases has been accompanied by Hypopion, turbid aqueous humour, a swollen, yellowish, or yellowish and vascular iris.

As regards the course of suppuration, it must be remarked that the rapidity of progress, and the extent of suppuration, are greatly influenced by the general health of the patient, the cause of the suppuration, by the state of the deeper parts of the eye, and lastly, by the treatment. Purulent and diphtheritic ophthalmia, unless they have passed the acute stage, may cause suppuration of the cornea within twenty-four hours. During acute pustular corneitis an abscess may have formed within twelve hours. Increased vascularity and swelling, and a greyish colour of the cornea next the seat of suppuration, with increased watering, indicate an arrest of the suppuration.

Treatment.—Our object in the treatment of suppuration of the cornea, besides attending to the state of the conjunctiva, to complications—as iritis—and to the preservation of the normal curvature of the cornea by a pressure bandage, is to check the suppuration. An important means of effecting this is the application of warmth or cold according to the indications; the latter has a depressing effect, while the application of warmth is stimulating: and some tact is required in determining whether cold or warmth should be applied at a given stage. The same case, according to the too great or too little amount of reactive inflammation, may repeatedly require a change from cold to warmth.

The frequent application to the closed eyelids of lint dipped in cold water is indicated if the suppuration is accompanied by a sensation of heat with much pain. These applications are discontinued as soon as cold is no longer pleasant to the patient.

Warmth or cold are applied by means of square pieces of lint (large enough to cover the eyelids and eyebrows), which are dipped into water, and squeezed out sufficiently to prevent the fluid from running over the patient's cheek. These, in severe cases, may, for one or two days, have to be changed every five or ten minutes.

The temperature of warm applications must be the higher the more quickly we wish to produce vascularity (reaction) at the seat of suppuration, e. g. if the latter extends rapidly while the vascularity and sensation of heat are moderate or absent.

Signs of reaction, and an indication to diminish or stop the warm applications, are swelling and opacity of the cornea round the suppurating portion, with increased vascularity, intolerance of light, and a sensation of heat. In addition to these applications we adopt the local and general medical treatment of ulceration of the cornea.

Opening of the abscess by incision has proved of great advantage in cases in which no perforation had occurred. This little operation consists in thrusting the point of a cataract knife, close to the suppurating part, through the healthy cornea into the anterior chamber, carrying it on so as to make an incision through the largest diameter of the suppurating portion, and bringing the point out again in the healthy cornea. The pus which is not washed away by the aqueous humour while completing the incision, should be removed with a small scoop; after which any grey and opaque substance lining the walls of the abscess must be torn away with the forceps or sharp hook. The lids, after the operation, are kept closed by a bandage, and atropia is applied twice daily until an opaque cicatrix has formed.

Tapping (*Paracentesis*) of the Aqueous Chamber.

With a cataract knife a puncture or incision is made through the

cornea, near its lower and outer margin. Prolapse of the iris and anterior synechia are less likely to follow if the incision is carried very obliquely through the cornea. The point of the knife, after having entered the anterior chamber, is directed forwards towards the cornea (to avoid wounding the iris), and should not pass beyond the margin of the pupil. The wound in the cornea having reached a width of about $\frac{1}{8}$ inch, the knife should be withdrawn slowly, when the fluid in the aqueous chamber is expected to escape. A curette is inserted between the lips of the incision if the fluid does not escape while withdrawing the knife.

Keeping the eyelids open with the wire speculum, and fixing the eyeball with forceps, cause much pain and straining. We must give chloroform when using these instruments, or perform the operation without them.

Syndectomy.

Syndectomy signifies excision of a large zone of conjunctiva and sub-conjunctival tissue from near the cornea.

The great pain, bleeding, &c., render the operation very tedious when performed without chloroform. The eyelids being kept open by the wire speculum, an incision is made with blunt-pointed (strabismus) scissors, about $\frac{1}{3}$ inch from the margin of the cornea, through the conjunctiva, and is carried all round and parallel with that margin.

The conjunctiva, together with all the sub-conjunctival tissue which lies between the cornea and the incision, is then dissected from the sclerotic, together with some of the vascular substance upon the cornea. Small portions of conjunctiva near the upper and lower margins of the cornea, left for the purpose of rotating and fixing the eye during the dissection, are removed last. Particular care should be taken to cut and tear away all the blood-vessels and connective tissue from the part of the sclerotic which is situated between the margin of the cornea and the insertions of the tendons of the recti-muscles.

The patient, after the operation, should remain in bed, and the eyelids should be kept closed, and lint dipped in cold water applied frequently. In some cases, on the fourth day, an opaque greyish-white substance (lymph?) is observed covering the exposed sclerotic. In most the sclerotic becomes covered with granulations.

The swelling of the conjunctiva subsides gradually; its free margin approaches the cornea, and after from two to three weeks we find in most cases a smooth substance covering the sclerotic. Twenty-four hours after the operation the surface of the cornea appears smoother, but more nebulous. On the eighth day most of the blood-vessels upon it have disappeared, and the cornea becomes more transparent.

ANÆSTHESIA.

Loss of Sensibility of the Cornea.

Anæsthesia of the cornea has been observed during various morbid changes, e. g. in the course of syphilitic corneitis, in some kinds of corneal ulcers, and in rapidly-forming protrusion of the eyeball; also from impaired functions of the ciliary nerves caused by ciliary staphyloma, by increased tension of the eyeball, &c., &c.

The anæsthesia may be partial or complete. The ophthalmia which often accompanies it is termed *Neuroparalytic Ophthalmia.*

Incomplete division of the fifth nerve on one side is followed (in rabbits) by opacity of the cornea of the corresponding side. The opacity after having reached a certain density diminishes again.

Complete division of the semilunar ganglion always produces the same corneal changes, i. e. a complete anæsthesia of the cornea, followed, after a few hours, by slight, and after 24 hours by marked, central opacity. The epithelium on the surface of the cornea becomes dry (on account of the too small quantity of tears secreted), and the cornea more and more opaque and yellow. The conjunctiva, sub-conjunctival tissue, and the sclerotic (in the ciliary region) become vascular and slightly chemotic in from 12 to 18 hours after the operation. Though occasionally pus may be formed within the eye, and the entire cornea become yellow and opaque, yet perforation of the cornea never occurs. The morbid changes, observed within the eye, are consecutive to those in the cornea. All these changes of the cornea are attributed to its inability (from anæsthesia) to protect itself against external injuries.

The desire of the cornea for moisture, the reflex action upon the lachrymal gland, and protection (by the timely closure of the eyelids) are wanting. The lids remain open too long, and dust, air, and other external irritants induce the above-mentioned changes, which on the other hand do not occur if ptosis exists simultaneously, or if the eyelids are kept closed.

In man a roundish opacity in the lower half of the cornea, with anterior synechia, indicates the spot where suppuration from anæsthesia has occurred. If the anæsthesia is complete we observe the cornea to become opaque, yellowish white, softened, ulcerated (the ulceration advancing from the superficial towards the deeper layers), and finally perforated. These corneal changes, with the so-called neuroparalytic ophthalmia, occur whether the trunk of the fifth nerve be implicated or not, as long as the cornea itself is anæsthetic.

Treatment.—Protection of the cornea, by keeping the lids continually closed with a piece of sticking plaster, or with a bandage, effectually prevents the above changes, or leads to rapid recovery if they have appeared.

Increase of tension is one of the most common intraocular causes of the anæsthesia, and requires iridectomy; if this has failed to effect a cure, and if the eye be blind and painful, excision of the eyeball is advisable. Incisions into an anæsthetic cornea heal readily.

The general medical treatment depends upon the cause of the anæsthesia.

ULCERATION OF THE CORNEA.

An ulcer of the cornea is generally accompanied by corneitis, by more or less vascularity of the conjunctiva and of the sclerotic, and by some swelling of the eyelids. To ascertain the seat and extent of a small or superficial ulcer the surface of the cornea may have to be examined with lateral illumination. The surface of the cornea at the seat of the ulcer is uneven and depressed from destruction of epithelium, anterior elastic lamina, and more or less of the lamellated tissue of the cornea.

We must direct our attention to the margins, the walls, and the base of the ulcer, and to the cornea adjoining it.

An abrupt margin, whether it be transparent or opaque, indicates spreading of the ulcer towards that side. A smooth margin, which gradually merges into the adjoining cornea, or a highly vascular margin, indicates a tendency of the ulcer to heal.

On minute examination we find in the semiopaque walls of the ulcer swollen corneal corpuscles, and nuclei. These decrease in number from the surface of the ulcer towards the cornea. The walls of an ulcer are generally uneven from unequal destruction of the corneal lamellæ. Some lamellæ may remain transparent while others become grey or yellow and opaque.

Anæsthesia of the base of rapidly-spreading ulcers is often observed. The base may yield to the pressure of the aqueous humour, and project into, or beyond, the area of the ulcer. This by some is termed *Keratocele*, or hernia of the cornea. The Keratocele has the appearance of a transparent vesicle at the base of the ulcer. It resists the pressure of the aqueous humour often for weeks. A cicatrix may form without the occurrence of perforation, or only after repeated perforations.

Perforation of the ulcer by the aqueous humour occurs either spontaneously, or is caused by pressure on the eyeball, e. g. during forcible separation of the lids. The sudden severe attack of pain felt at the moment of perforation, soon subsides, if the aqueous humour only has escaped. The opening either heals, or repeated perforations may occur without the iris or any other part becoming permanently disturbed. Frequently, however, part of the iris becomes adherent to the margins of the ulcer, and so-called *Anterior Synechia*, with more or less distortion of the pupil, is the result.

The part of the iris which closes the opening of perforation, especially if that opening be large, often yields to the pressure of the aqueous humour, and becomes more or less *staphylomatous*. It gradually becomes covered with granulations, which finally change into opaque tissue. The pupil, if exposed, likewise becomes covered with lymph.

Staphyloma of the iris occurs more frequently if the crystalline lens has not escaped after perforation. The staphyloma (of the iris and of the surrounding "opaque" cornea), if examined minutely, is found covered with several layers of epithelial cells, which differ in their arrangement from those upon the healthy cornea. The anterior elastic lamina abruptly surrounds the base of the staphyloma, while the posterior elastic lamina may be seen interposed between the staphyloma and the cornea.

In the opaque tissue covering the iris we occasionally observe one or several fistulous openings, especially if the margin of the pupil is near the seat of perforation. These openings appear as dark spots, and lead into the posterior aqueous chamber.

The capsule of the lens may, like the iris, undergo adhesion to the margins of the perforation. If the lens remain for a longer period in contact with the inflamed cornea, morbid changes may occur in the intra-capsular epithelium, and in the adjoining fibres of the lens. Such changes have been followed by so-called anterior polar cataract, or by opaque spots upon the surfaces of the capsule.

If the perforation is large, or occurs while much pressure is made upon the eye, part, or the whole of the lens, or some vitreous substance, or both conjointly, may escape. Gradual shrinking of the eye, sometimes preceded by ophthalmitis, or by hæmorrhage into the eye, may follow. The shrunken and soft eye may retain some perception of light.

Healing of the Ulcer. Ulcers, as a rule, heal rapidly after perforation has occurred, probably because the tension of the cornea is diminished, and the blood necessary for repair more readily admitted.

In most cases a semitransparent swollen portion of cornea intervenes between the healthy part and the ulcer. In the swollen portion blood-vessels appear, which come from the conjunctiva, and sometimes from the entire thickness of the sclerotic, and assist in the healing process. At this stage we may find the area of the ulcer covered with granulations and with blood-vessels, which latter disappear as the healing process advances.

The degree of lachrymation, of intolerance of light, and of pain, and the amount of spasmodic closure of the lids, vary considerably during the healing. They are looked upon as favourable symptoms, especially if they have been absent at the outset of the ulceration.

Small and shallow ulcers, or even large ones, if occurring in children, may heal without leaving an opacity, the loss of substance being repaired

by transparent tissue. A shallow depression may remain in the otherwise transparent cornea.

"Opacity of the cornea," however, is the usual result after the ulcer has disappeared.

VARIETIES OF ULCERS.

The Marginal Crescentic-shaped Ulcer.

The margin of the ulcer which lies furthest from the sclerotic, is abrupt, and well-defined. The ulcer spreads from this margin, and may gradually implicate the entire surface of the cornea and the deeper layers; sometimes only the posterior elastic lamina remains intact.

The healing of this ulcer commences at the margin nearest the sclerotic. Large vessels, which sometimes bleed considerably, pass into the ulcer from the adjoining conjunctiva, sclerotic, and cornea. The loss of substance is filled up by opaque or semiopaque material.

The marginal ulcer is often preceded by, or complicated with, iritis.

This kind of ulcer is one of the dangerous complications of severe purulent ophthalmia.

The Marginal Irregularly-shaped Ulcer.

This kind of ulcer, while healing in one, appears in another part of the cornea, leaving the previously attacked portion opaque. Perforation occurs frequently. The ulcer may persist for years and the eye finally be destroyed. Of all remedies tried, syndectomy has been the only one from which immediate benefit has been derived.

The Transparent Ulcer.

This ulcer has been observed spontaneously and in the course of severe purulent opthalmia. Its margins are either abrupt or shallow; they, as well as the base, are transparent. For months the ulcer may appear on the verge of perforation, yet finally heal under the influence of vascular corneitis.

Causes of Suppuration and of Ulceration.

Injuries, especially blows, concussions, wounds inflicted with rusty instruments, &c., foreign bodies in the cornea.

Scratches with the nail of the finger, with a wheat-ear, &c., especially when occurring in elderly or weakly persons, are peculiarly liable to be followed by rapid suppuration, or by large flat ulcers, with comparatively little vascularity and with slight intolerance of light. In these cases hypopion and iritis are common complications.

Other causes are—chemical injuries, burns, anæsthesia of the cornea, and the contact of pus of purulent opthalmia.

In some persons a clean incision of the cornea, or simple superficial corneitis, may be followed by suppuration.

Corneitis, abscesses, ulcers, &c., frequently appear in the course of the so-called Exanthematous Opthalmia, which is observed during recovery from erysipelas, scarlatina, measles, &c.

Fever and diarrhœa, especially in children, may produce the same.

Treatment.

1. We first ascertain whether the ulcer is complicated with granular ophthalmia, or whether there is a foreign substance in the cornea or conjunctiva. The removal of the offending substance and rest, and in the former case the active treatment of the granulations, succeed in most cases in arresting the ulceration.

2. For treatment of ulcers or of suppuration, occurring in the course of severe purulent or gonorrhœal ophthalmia, see Purulent Ophthalmia.

3. In ulceration from other causes we must insist upon the careful and continued application of slight pressure, by means of a bandage applied over the closed eyelids. We thus insure rest, promote healing of the ulcer, and prevent staphyloma. The bandage is removed only to apply lotions, &c. A large prolapse of the iris so treated may heal with an opaque, non-staphylomatous cicatrix, even after all the cornea has been destroyed; and we may succeed in obtaining a cicatrix, which admits of the wearing of an artificial eye, without any further operation being required.

If, after perforation, the lens with its capsule is exposed, a large portion of the cornea having been destroyed, we puncture the capsule of the lens, and thus cause the latter to escape spontaneously. This often prevents the formation of staphyloma.

We should recommend iridectomy if the ulcer is near perforation, or if it is spreading rapidly. The insertion of a seton into the temple should be advised, if iridectomy is objected to, and if there is intolerance of light and much increase of vascularity. Puncturing the thinnest part of the ulcer, to allow the aqueous humour to escape slowly, may prevent the occurrence of a large opening of perforation.

We may be compelled to resort solely to medical agents. In all cases atropia should be applied (from four to six times daily), and also to the not inflamed eye, if absolute rest be required. Its application must be continued until the ulcer has healed. Calabar is recommended if the ulcer is near the margin of the cornea, or if perforation has happened with a small prolapse of iris.

If the least mucous or purulent discharge is present (causing the eye-

lids to be gummed up), slightly astringent lotions, e.g. the Lotio Aluminis, are indicated to wash the eyelids twice daily. The lotion must be diluted if the pain caused by it continues for more than one or two minutes. Care should be taken not to order lotions or drops which are likely to leave a precipitate on the surface of the ulcer, e.g. lotions containing lead. Opacities thus produced can be removed by operation.

In chronic ulcers, where there seems to be a want of reparative power from too little vascularity round the ulcer, frequent bathing with warm water is indicated.

For further treatment, see Opacities, Staphyloma, and Fistula of the Cornea.

Iritis is a common complication, and requires the frequent application of atropia.

If ophthalmitis should set in, as has occurred in syphilitic persons and in those weakened by scarlatina, &c., excision of the eye should be recommended. Warm fomentations, or linseed-meal poultices, are applied over the closed eyelids, if the operation is objected to.

It is of importance to adopt an appropriate general medical treatment. Arsenic with steel will be found of use in ulcerations accompanying pustular corneitis, and in the marginal ulcer with much vascularity.

Steel, generous diet, and wine or brandy, should be given in ulcers with suppuration of the cornea, and with little or no intolerance of light.

OPACITY OF THE CORNEA.

Differences of colour, shape, structure, origin, &c., of the opacity, have given rise to various terms.

Nebula signifies a semitransparent, bluish, or greyish opacity, which shades off into the normal tissue. A cornea with one or several nebulæ is termed nebulous ; the nebulæ may be superficial (in front, or immediately beneath the anterior elastic lamina) or deep-seated.

The substance which gives rise to superficial nebulæ, when examined microscopically, and in sections, appears granular, very dark, and situated immediately beneath and upon the anterior elastic lamina. It consists of ill-shaped corneal and epithelial cells, of obliterated blood-vessels, and of slightly opalescent lamellæ of the cornea.

Causes.—Corneitis (especially the syphilitic form), slight pannus, and ulcers (the loss of substance having been repaired by semitransparent material).

Leucoma (*Albugo, Fibrous Opacity, Cicatrix in the Cornea*).

The term leucoma is applied to a dense white or grey opacity, which occupies the place of the entire (Total Leucoma) or of part of the cornea

(Partial Leucoma), and which prevents a view of the parts behind it. The leucoma may have the colour of chalk or of fibrous tissue. It may be well-defined, surrounded by cornea, or shaded off. It may extend to a limited depth into the cornea, or occupy its entire thickness, and likewise project beyond its curvature.

The leucoma may become staphylomatous or ulcerate. Several leucomata may stand side by side, e. g. when the result of severe pustular corneitis. Large blood-vessels pass sometimes through the leucoma.

In leucoma, as in nebula, we sometimes find (on microscopic examination) the opacity to consist of new, ill-shaped cell-strata, situated between the lamellæ of the cornea or accumulated in one spot. In other cases the lamellæ themselves appear opaque, with a grey, or yellow, or brown powdery substance, with debris of blood-vessels and with granules of chalk accumulated between them. Such leucomata occur after severe syphilitic or after slight suppurative corneitis.

In leucoma following ulceration we sometimes find the lamellæ of the cornea semitransparent, and covered with opaque epithelial cells, while the anterior elastic lamina is found missing to the extent of the leucoma.

The leucoma, which is developed out of the lymph which covers a prolapse of the iris, frequently becomes staphylomatous. Examined microscopically and in transverse sections, it may present the appearance of vascular papillæ, cut transversely.

A leucoma occupying the entire thickness of the cornea, is generally complicated with anterior synechia.

The presence of pigment or blood, or of adhesions of the iris or of the lens, gives rise to reddish, brownish, or bluish spots, which are mixed up with the original white and opaque colour of the leucoma.

Clavus or Myocephalon with some signifies a deposit of pigment in a leucoma; with others the term is confined to a black or bluish black spot in the nebula, or in the leucoma, which spot is caused by uvea, covered by a thin layer of the fibres of the iris or by semiopaque connective tissue.

The myocephalon is frequently staphylomatous; and not seldom an opening (fistula) is observed in it leading into the posterior aqueous chamber.

Chalky or bony substance is found more particularly if extensive suppuration have preceded the leucoma.

Opacities of a well-defined white, or yellowish-white, or brownish, or even black colour are occasionally observed after using lotions containing acetate of lead or phosphate or carbonate of lime.

Particles derived from these salts, of which the sugar of lead is the one most frequently used, become deposited and fixed among the granulations of the ulcer.

The opacity may occur symmetrically in both corneæ; it may change colour as it becomes older, or may remain stationary for years.

Greyish-white, yellowish, brownish, or black minute dots, situated at different depths in the cornea, and more frequently in its lower half, occur especially after syphilitic corneitis. If seated in the epithelial layer, they have been found to consist of clusters of altered epithelial cells. These, with some of the adjoining anterior elastic lamina, have been removed successfully by operation.

Round bright-red spots, consisting of blood effused among the lamellæ of the cornea, have been observed. One of these, of several months' duration, has been removed successfully by operation.

Vision.

The disturbance of vision observed with opacities is to be attributed partly to loss of transparency of the cornea, partly to diffusion of light, and partly to alterations of curvature. Hardly perceptible opacities (nebulæ), especially if opposite the pupil, very much impair vision by diffusing the light instead of allowing it to become regularly refracted. The greater the quantity of diffused light which reaches the retina, the more misty do objects appear. If such an opacity occurs only in one cornea, and an object is viewed with both eyes, an impression is produced as if a mist intervened between the eyes and the object. Patients complain of "the sight of the one eye dazzling that of the other;" and frequently close the eye with the opacity, or "squint," while reading. If opacities occur on both corneæ, the best eye is used by preference. In children nystagmus frequently becomes developed.

A larger field of vision is obtained if the inner half only of the pupil is obscured by an opacity. Patients with opacity, when looking at near objects, and using the defective eye, see better when turning the back to the light. Amblyopia sometimes ensues from the retina not receiving good impressions, and may continue after the opacity has disappeared.

Small and dense opacities (Leucomata) at or near the middle of the cornea, cause no diffusion of light, or much less than nebulæ.

Besides the diffusion of light and the disturbances caused by alterations of curvature, we occasionally observe, after ulceration or suppuration, that some change has occurred in the arrangement of the lamellæ of the cornea. In such cases the cornea may have again become transparent and may appear of normal curvature, as far as can be ascertained by the shape of reflex images. The contours of the optic disc, and of the retinal vessels, viewed through those parts of the cornea, appear distorted, like objects viewed through flaws in glass.

Treatment (1) *by Medical Agents.*—The more recent or the thinner the opacity, and the younger the patient, the greater are the chances of im-

provement. A considerable portion of the cornea, when destroyed, may become replaced by transparent substance. In children the growth of the cornea in itself materially assists in the removal of opacities. Thus opacities following purulent ophthalmia, and occupying nearly the entire cornea, may, without any treatment, disappear within two years; while in adults even slight opacities often remain for life.

Densely opaque, bony, earthy, or metallic deposits remain unchanged unless very near the surface of the cornea. In the latter case earthy deposits have been known to become eliminated slowly, and with much irritation.

Dense opacities, if confined to one eye, the other being undisturbed, are best left alone, unless they lie opposite the pupil, when surgical interference is indicated.

Changes in the eyelids and conjunctiva (Tinea, Trichiasis, Granulations, &c.), tending to maintain the opacity, must first be removed by treatment.

The object of medical agents, applied to the cornea for the removal ("absorption") of opacities, is to produce an irritation in the cornea, or, strictly speaking, slight corneitis. Dense opacities have been known to disappear spontaneously during an attack of purulent ophthalmia causing corneitis.

No irritating remedies should be used as long as undue sclerotic or conjunctival vascularity, pain, watering, intolerance of light, or increased sensation of heat exists.

The symptoms of irritation produced artificially, are—increase of vascularity of the conjunctiva, sclerotic, and cornea; watering, intolerance of light, and pain. The pain following the application of local remedies should last from five to ten minutes. The duration of the pain affords the means of measuring the amount of irritation produced. The patient has to find by experiment what strength of the lotion, &c., suits him best. He should be told that if the pain lasts longer than fifteen minutes, the remedy, lotion, &c., has to be made weaker. Changes in the strength of the remedies may be required at different periods. Lotions or drops produce less irritation than ointments.

The remedies which are in general use in the treatment of opacities are—*Calomel Powder*. It is best suited if the eye is irritable.

Oleum Terebinthinæ, mixed with varying proportions of olive oil, commencing with one part of the Oleum Terebinthinæ to four parts of the Oleum Olivarum.

Pure Oleum Terebinthinæ is prescribed if much irritation is required.

Sulphate of Copper, Acetate of Lead, Nitrate of Silver, &c., have been superseded by the Oleum Terebinthinæ.

Guttæ Potassii Iodidi (gr. ii. Potass. iodid. ad aquæ destill. ℥ i.) produce the smallest amount of irritation.

Tinctura Opii, mixed with varying proportions of water, according to the irritation required, is recommended to induce repair of indentations left in the cornea after ulceration. The smarting sensation produced by the lotion, when applied to the conjunctiva, should not last longer than about ten minutes.

The above remedies may be tried in all kinds of corneal opacities. They are useless if applied to opaque cicatrices of the iris, the latter being adherent to the cornea. Calomel powder is particularly recommended in opacities following pustular corneitis ; Oleum Terebinthinæ in the nebulous condition caused by syphilitic corneitis. The remedies should be applied from three to five times daily, and continued for several months. The drops and the calomel powder are applied with a camel's hair brush three times daily ; the lotions by bathing the eyelids ; the ointments by placing a small quantity upon the conjunctiva.

An examination of the field, and of the acuteness of vision, should be made from time to time, to ascertain the progress made. The local applications must be discontinued if no decided improvement of vision is observed after from two to six months.

Treatment (2) *by Optical Means.*—In persons with opacity of the cornea of both eyes (or of one, the sight of the other having been lost) we should carefully ascertain whether vision can be usefully improved by stenopæic remedies, or by cylindrical or spherical lenses.

Stenopæic remedies limit the field of vision, and are only applicable for reading and near work. Their object is to cause a limited portion of the retina to be strongly illuminated, while the light is kept completely excluded from the rest.

We first, by lateral illumination, ascertain the density and size of the opacity ; and then, by experiment, find the size and the direction of the opening, which, held closely in front of the best part of the cornea, most improves the patient's vision. During these experiments all side light must be excluded, and a point of light be used as the object for the patient to look at. Having found the opening which suits best, a pair of stenopæic spectacles is prescribed having the proper opening. The patient must be shown in what position to hold objects so as to derive most benefit from the spectacles.

Spherical (the usual convex and concave) and cylindrical lenses, and likewise the effect of atropia and of calabar, should be tried.

These remedies are sometimes of benefit only after the application of surgical means, e. g. after an iridectomy.

Vision for distant objects, unless the opacity be very faint and the curvature of the cornea but slightly altered, is rarely improved by spectacles.

It is more particularly for reading and "near work" that optical means are of use.

In the selection of spectacles we must be guided by the rules laid down under myopia, hypermetropia, and especially under astigmatism.

Treatment (3) *by Surgical Means.*—The operation for artificial pupil should be recommended if the opacity is dense and opposite the pupil, the rest of the cornea being clear; or if the operation is likely to increase the field of vision or the quantitative perception of light. Every case requires special study as regards the modification of the operation. The artificial pupil should be made behind the most transparent portion of cornea, and should be as central and defined as possible.

Iridesis displaces the pupil towards the incision in the cornea, and may thus remove it altogether from behind the opacity. If we have the choice, we make the new pupil inwards and downwards.

We make the artificial pupil near the upper margin of the cornea if only one eye is left, or if both are similarly affected, the upper part of the cornea alone being clear. In these cases we also divide the upper and lower recti muscles, and advance the insertion of the latter, so as to carry the artificial pupil more into the area of the palpebral aperture. Iridectomy, or a large artificial pupil, is preferable if the cornea is nebulous; and especially if the reflex images of its surface indicate much irregularity.

Changes in the curvature of the cornea may render the best-performed operation useless. We should, therefore, previous to operating, be careful to dilate the existing pupil, and with the ophthalmoscope and with stenopæic remedies ascertain the healthiest part of the cornea (see Conical Cornea); or if these means of examination are inadmissible, we should determine what part of the surface of the cornea furnishes the most perfect reflex images.

We again try optical means, especially cylindrical lenses, after all vascularity and opacity caused by the operations have subsided.

Anterior synechiæ, if complicating the opacity, should be carefully divided. A large opacity sometimes disappears spontaneously after this little operation.

Removal of opacities by operation has been followed by corneitis, iritis, and even by suppuration of the eyeball. In most cases, however, it has been successful. Only one eye should be operated upon at a time; and, as a rule, chloroform should be given.

Dense superficial opacities, whether prominent or not, especially if they seem to irritate the eyelids, may be shaved off with a cataract-knife.

When removing an opacity by operation we sometimes, to reach it, have to scrape away some epithelium. The opacity itself is often hard, friable, and rests upon semitransparent or vascular cornea. When seized with the iris forceps it can generally be broken away in small particles,

or peeled off altogether. It may have to be scraped away with the broad needle.

After the operation both eyes must be kept closed for from three days to a week; and lint dipped into cold water should be applied to the lids. Atropia and leeches to the corresponding temple are ordered if iritis threatens.

Corneal opacities with fistulous openings are treated by iridectomy. The fistula becomes closed within a few days after the operation. All iris round the fistula, and between it and the nearest margin of the cornea, should be included in the iridectomy.

ANOMALIES OF THE CURVATURE OF THE CORNEA, AND STAPHYLOMA.

Astigmatism (α priv. and στιγμα, from στιζω) of the Cornea (Asymmetry of the Cornea).

Astigmatism is the result of anomalies of the curvature of the light-refracting parts of the eye. A cornea is termed astigmatic if the rays of light which pass through some parts of the cornea, are brought to a focus sooner or later than rays passing through other parts. This difference in the refraction of the rays causes the images of objects from which they proceed to become imperfectly formed upon the retina, and to appear more or less distorted or indistinct.

Measurements of the cornea of the living eye, and the results of treatment of astigmatic persons, have shown that the cornea is the part which, through being astigmatic, most frequently gives rise to disturbances of vision.

It has been found: (1.) That the curvature of the cornea from above downwards, i. e. in its vertical meridian, is as a rule greatest, and that therefore the rays passing through this meridian are refracted more, and brought to a focus sooner. In other words, the radius of curvature of the cornea is shortest in the vertical meridian.

(2.) That the curvature of the cornea from side to side, i. e. in its horizontal meridian, is least. The rays passing through this meridian are refracted less, and brought to a focus further behind the cornea. In other words, the longest radius of curvature corresponds to the horizontal meridian of the cornea.

The meridian of greatest curvature (the most convex part of the cornea) and the meridian of least curvature (the least convex part of the cornea) are termed the two chief, or principal, meridians of the cornea.

The astigmatism which is the result of asymmetry of curvature is termed *regular astigmatism of the cornea,* and is the kind of which we shall treat in this chapter.

Irregular Astigmatism exists if the rays which pass through one meridian of the cornea, or of the crystalline lens, or of both, are not brought to a focus, but are refracted irregularly.

General Remarks.

Astigmatism is often inherited, and generally presents the same form in parent and child. It is as a rule congenital, is observed in both eyes, but disturbs vision sensibly only when exceeding a certain degree. It is sometimes acquired.

Vision.

The nature of the disturbance of vision, e. g. during reading, will be better understood by entering more minutely into what is necessary to see letters distinctly. Suppose letters to consist chiefly of vertical and of horizontal strokes, and these to be situated in the same plane and to stand close together. If the vertical strokes are brought to a focus in the retina, but not the horizontal ones, the margins of the latter appear diffused and drawn out, and their recognition is impaired according to the degree of diffusion. Even the vertical strokes appear confused if the diffusion is great, and the strokes are close to each other.

Take e. g. the letter H, which consists of two long vertical, and five shorter horizontal strokes. To see the vertical strokes distinctly it is necessary that the rays, which come in a horizontal direction from each point of the margins of the vertical strokes, should be brought to a focus in the retina. Each point of the stroke sends out a diverging bundle of rays. Those which diverge from each point in a vertical direction little disturb the distinctness of the image of the point, if they are not brought to a focus in the retina, since they merge into those coming from adjoining points above and below. But those which diverge in a horizontal direction from each point of the vertical stroke form a diffused image of the point, if they are not brought to a focus in the retina.

The distinctness of each stroke of a letter depends on the distinctness of its outlines. A vertical stroke appears diffused, if those rays of light are not brought to a focus which come in a horizontal direction from the points which form the outline of the stroke (and which pass through the horizontal meridian of the cornea). Some idea of this may be formed by tracing a series of minute black dots side by side in a vertical direction, so that one dot a little overlaps the next one. It will then be found that the distinctness of the margins of the line, thus formed, does not depend upon the definedness of the dots in the vertical, but upon that in the horizontal direction. The more ill-defined the dots are, the more indistinct do the margins of the stroke appear in the direction in which the dots do not overlap each other. It follows from the above, that to see a

vertical line distinctly, the rays which come from it in a horizontal direction must come to a focus; and to see a horizontal line distinctly, those coming from the line in a vertical direction must be brought to a focus.

If the letter H, instead of appearing defined, is seen thus H, we infer that the rays passing through the vertical meridian of the cornea are brought to a focus in the retina; but that the rays coming from the letter in a horizontal direction are not brought to a focus in the retina. The horizontal meridian of the cornea is at fault if objects appear drawn out in a horizontal direction.

If the letter H appears thus H, it follows that the rays coming from it in a vertical direction are not brought to a focus in the retina; and if objects appear drawn out in a vertical direction, we infer that the rays coming from them in a vertical direction are not brought to a focus. Horizontal lines, therefore, to appear well defined, have to be held nearer than vertical lines, if the cornea in the vertical meridian is more convex, i. e. if its focal distance is shorter in that meridian. To see horizontal lines distinctly, it is chiefly necessary that rays coming from them in a vertical direction come to a focus in the retina. To see vertical lines acutely, it is necessary that the rays coming from them in a horizontal direction should be brought to a focus in the retina.

Slight degrees of astigmatism give rise to *disturbances of vision* about middle age; while in high degrees the acuteness of vision is generally diminished, and sometimes a high degree of amblyopia becomes developed, even very early in life.

The asthenopia, from which astigmatic persons frequently suffer, is the result of undue and of irregular contraction of the ciliary muscle. The asymmetry of the curvature of the cornea in itself diminishes the acuteness of vision; so that even larger objects, to be seen distinctly, are held close to the eyes. This is necessarily accompanied by increased convergence and accommodation of the eyes, and finally is followed by asthenopia.

In the higher degrees we find that vision has never been perfect; and reading has always been more or less troublesome, and little improved by spectacles. The forms of objects are recognized imperfectly. The positions of objects in the field of vision are correctly stated, but their shape and colour appear altered, as they are only recognized with difficulty.

Some patients complain of seeing objects double, treble, &c. (*Polyopia*), with one eye. This indicates an asymmetry in the curvature of the different meridians of the crystalline lens. Each sector of the latter forms a separate image, and the imperfect coalescence of these images in the retina gives rise to the polyopia. When viewing a point of light, e.g.

the flame of a candle's rays of light appear to shoot out from the flame. The polyopia is the less observed the more perfect the power of accommodation.

Forms of Astigmatism.

The changes of curvature of the cornea, which give rise to astigmatism, are too great or too slight convexity of the cornea; in other words, too short or too long a radius of curvature.

Too great convexity of the cornea causes parallel rays of light to come to a focus in front of the retina. The eye becomes "myopic:" and the form of astigmatism, caused by too great convexity of the cornea, is termed *Myopic Astigmatism.*

This form of astigmatism is termed *Simple*, or *Simple Myopic Astigmatism,* if there is myopic astigmatism (exceeding $\frac{1}{40}$) only in one of the two chief meridians of the cornea, the other meridian being emmetropic. We have *Compound Myopic Astigmatism* if myopia exists in both the chief meridians, exceeding $\frac{1}{40}$ in each. If we find in one chief meridian myopia of $\frac{1}{10}$ (= Am. $\frac{1}{10}$ i. e. myopic astigmatism = $\frac{1}{10}$), and in the other myopia of $\frac{1}{20}$ (= Am. $\frac{1}{20}$), we have myopia of $\frac{1}{20}$ in both, and an additional $\frac{1}{20}$ in one of the two chief meridians, and we write M $\frac{1}{20}$ + Am. $\frac{1}{20}$.

Too slight convexity of the cornea causes the rays of light to come to a focus behind the retina, and gives rise to *Hypermetropic Astigmatism,* which may again be *simple* or *compound.*

Mixed astigmatism exists if we find hypermetropia in one chief meridian, and myopia in the other.

If the myopia predominates, we write amh, i. e. astigmatism (= a), with myopia (= m) in one, and with hypermetropia (= h) in the other chief meridian. We write ahm if the hypermetropia (= h) predominates.

Hypermetropic astigmatism is the more frequent form. It has been observed, that out of six hypermetropics one suffers from an abnormal degree of astigmatism, and more often in the horizontal meridian of the cornea.

Diagnosis.—Certainty as regards the existence of astigmatism is obtained :

1. By ascertaining the degree of curvature of the cornea in the different meridians, with the aid of optical and mathematical instruments; and

2. By examination with spherical and cylindrical lenses, assisted by the stenopæic apparatus.

The latter (2) is the mode usually adopted.

We first have to find the direction in which the cornea is most, and the one in which it is least convex (its maximum and minimum degree of curvature); in other words, we ascertain its two chief or principal meridians. To do this the patient is placed in a dark room, and at about 15′ from

a screen in which is a round opening about $\frac{1}{7}''$ in diameter. Behind the opening stands the flame of a lamp. The eye not under examination is kept closed, while the other eye is directed to the point of light. A weak convex and a weak concave lens of about 30″ focus (a $\frac{1}{30}$ and a $-\frac{1}{30}$) are now alternately held before the eye. The image of the point of light appears elongated in a different direction when viewed through $\frac{1}{30}$ than when seen through $-\frac{1}{30}$.

The two opposite directions in which it is elongated, indicate the direction of the greatest and of the least convexity of the cornea (the maximum and the minimum of its curvature), or the direction of its two chief meridians.

Having traced on paper the two directions in which the image of the point of light is elongated, we carefully ascertain the refraction of the eye. (See Refraction, mode of ascertaining it.) We then place the slit (about $\frac{1}{14}''$ wide) of the stenopæic apparatus (or a disc of metal or horn with a slit of that width in it) before the eye. The slit is held close to the cornea, and first in one, then in the other of the two directions in which the point of light has been elongated. If vision is not at all, or only slightly, improved, while the eye looks through the slit at the point of light, we hold in succession various spherical lenses close before the slit, commencing with the one which most improved the refraction of the eye.

We conclude that the degree of astigmatism is not sufficiently high to disturb vision, if the latter is not improved by the slit and by the spherical lenses. If vision is improved, we note the focal distance of the spherical lens which suited best, together with the direction of the corresponding chief meridian of the cornea.

The above examination may be assisted by the ophthalmoscope, or by lateral or direct illumination.

With the ophthalmoscope even slight degrees (from $\frac{1}{30}$ to $\frac{1}{20}$) of astigmatism may be recognized. Having brought the optic disc into view by the direct ophthalmoscopic examination, we look—

(1.) *For the blood-vessels of the retina.* We assume the existence of astigmatism, if the vessels which take a horizontal course are not seen with equal distinctness at the same time as those which in a vertical direction pass over the optic disc and adjoining retina.

(2.) *For the shape of the optic disc.* If the latter, when examining the erect image, appears more or less vertically oval, and, on altering our distance from the disc, changes into a more or less horizontally oval shape, we assume the oval shape of the optic disc not to be real, but to be the result of astigmatism.

A circular figure, viewed through refracting surfaces, of which the difference of curvature is greatest between their horizontal and vertical me-

ridians, appears transversely oval, if the rays which come from it (the circular figure) and which pass through the horizontal meridian of the rerefracting surfaces, do not come to a focus in the observer's retina. It appears oval from above downwards, if the rays which pass through the vertical meridian of the refracting surfaces do not come to a focus.

With lateral illumination.—In high degrees of astigmatism the images of objects reflected from the surface of the cornea appear irregular.

With direct illumination of the surface of the cornea with the ophthalmoscope.—We must observe (1.) Whether a shadow appears upon the surface of the cornea when throwing the light upon it, and (2.) Which is the long axis of the shadow. The curvature of the cornea is most altered in a direction at right angles to such axis.

The degree of astigmatism may be expressed by stating the difference of refraction which exists between the two principal meridians, i.e. between the meridian of the greatest and that of the least curvature of the cornea, as ascertained by spherical lenses and the stenopæic slit.

(1.) We state the degree of astigmatism to be equal to $\frac{1}{10}$, if, by the method detailed under diagnosis of astigmatism, we have found that vision in one of the two directions (i. e. in one of the two principal meridians) in which the point of light appeared elongated is most improved by a convex lens of 10″ focus, while in the other direction it is not improved by any means.

(2.) If we find vision most improved in one of the principal meridians by a concave lens of 10″ focus, and in the other principal meridian by a concave lens of 20″ focus, we state the degree of astigmatism to be $= \frac{1}{20}$. In this case the myopia in one chief meridian amounts to $\frac{1}{20}$, in the other to $\frac{1}{10}$ (or $\frac{2}{20}$). We have, therefore, myopia of $\frac{1}{20}$ in both chief meridians, and, in addition, myopia of $\frac{1}{20}$ in one. This is compound myopic astigmatism, and we write myopia $=$ M $\frac{1}{20}$ $+$ myopic astigmatism ($=$ Am $\frac{1}{20}$). (M $\frac{1}{20}$ $+$ Am $\frac{1}{20}$).

When prescribing spectacles for this case (supposing the astigmatism to be the same in both eyes), we give for each eye a concave lens, in which the one surface (the one which comes to stand next the cornea) has a spherical curvature (one in which the entire surface is concave), with a negative focal distance of 20″. This surface removes the myopia of $\frac{1}{20}$ which exists in each of the two chief meridians. But in one of these meridians we have found an astigmatism of $\frac{1}{10} = \frac{2}{20}$. $\frac{1}{20}$ has, as just stated, been removed by the spherical concave surface of the lens.

The second $\frac{1}{20}$, being the difference in the refraction of the two principal meridians, is removed by the other surface of the lens being ground cylindrically (concave only in one direction). The negative focal distance

of the cylindrical surface must be 20″. Such a lens is termed spherico-cylindrical.

The degree of the mixed astigmatism is expressed by separately stating the degree of each kind, e.g. if in one chief meridian vision is most improved by—$\frac{1}{10}$, in the other chief meridian by $+\frac{1}{20}$ we have in the former myopic astigmatism of $\frac{1}{10}$ in the latter hypermetropic astigmatism of $\frac{1}{20}$.

The degree of astigmatism is considered abormal if it exceeds $\frac{1}{40}$. $\frac{1}{20}$ or $\frac{1}{10}$ are high degrees. In speaking therefore e.g. of simple myopic astigmatism of $\frac{1}{30}$, it does not follow that no astigmatism exists in the other chief meridian, but only that it does not exceed a degree of $\frac{1}{40}$, i.e. that it does not create disturbances. The highest degree on record is $\frac{1}{4\frac{1}{2}}$.

Treatment.—The alterations of vision, which are the result of astigmatism, can be produced artificially by looking through a cylindrical lens, and may again be removed by placing in front of this a second appropriate cylindrical lens. The effects of regular astigmatism of the cornea upon vision can also in great measure be removed by cylindrical lenses. The reason why this cannot always be done is found in the complication of regular with irrregular astigmatism.

Having ascertained the presence of astigmatism, its kind (whether hypermetropic or myopic) and its degree in the two chief meridians, we place the patient at the distance at which he can recognize the letters of No. XX.

Suppose we have found that vision is most improved, when a spherical convex lens of $\frac{1}{20}$ is held close in front of the vertical meridian of the cornea; we thence infer the existence of *simple Hypermetropic Astigmatism* of $\frac{1}{20}$. From our box of cylindrical trial lenses we take a positive cylindrical lens of $\frac{1}{20}$, and while the patient is looking through this lens at the type, we rotate the lens until we have found in which direction of its axis vision is most improved. After this we try stronger and weaker simple positive cylindrical lenses, until we have found the one by which the most acute vision is obtained.

We proceed in the same way in *simple Myopic Astigmatism.*—Suppose we find —$\frac{1}{20}$ to be the spherical concave lens which improves vision most in the vertical meridian of the cornea, we repeat the experiments just stated, with simple, negative cylindrical lenses.

If only simple astigmatism has to be corrected, we must furnish the optician with the focal distance of the cylindrical lens, whether positive or negative, and with the requisite direction of its axis. It is, however, better that the optician should have a spectacle-frame with rings which allow of rotation, and into which the cylindrical lenses can be inserted, so

that the patient, at the optician's house, can determine the best direction of the axis of the cylindrical lens.

If we find *Compound Astigmatism,* we place into the spectacle-frame the spherical lens (convex for hypermetropia, concave for myopia) which has been ascertained as correcting an equal amount of hypermetropia or of myopia in the two chief meridians. For instance, if we find hypermetropic astigmatism of $\frac{1}{20}$ in the vertical, and hypermetropic astigmatism of $\frac{1}{10}$ $(= \frac{2}{20})$ in the horizontal, meridian of the cornea, we insert a spherical lens of $\frac{1}{20}$ into the frame. (The eye which is not under examination is kept closed.) While the patient is looking through $\frac{1}{20}$, a simple positive cylindrical lens of $\frac{1}{20}$ is held close in front of the spherical $\frac{1}{20}$, and, as in simple astigmatism, the direction of the axis is ascertained by which the greatest acuteness of vision is obtained.

The same proceeding having been adopted for the fellow eye, the optician is directed to furnish the patient with a pair of spectacles (supposing both eyes to be alike) with spherico-cylindrical lenses. In these should the spherical surface of each lens have a focal distance of 20″ and the cylindrical surface one of 20″ $(\frac{1}{20}{}^{s} \subset \frac{1}{20}{}^{c})$, taking care either to state accurately the necessary direction of the axis of the cylindrical surface, or to see that the patient, at the optician's house, is furnished with a spectacle-frame which allows of rotation of the cylindrical in front of the spherical lens, to ascertain the direction of the axis.

In compound myopic astigmatism we proceed in the same manner with concave spherical and with concave cylindrical lenses.

Mixed Astigmatism is very rare. It is relieved by the use of bi-cylindrical lenses. For example, if we find hypermetropia of $\frac{1}{10}$ in the horizontal, and myopia of $\frac{1}{20}$ in the vertical, meridian, we order spectacles with bi-cylindrical lenses $(= \frac{1}{10}{}^{c} \ulcorner - \frac{1}{20}{}^{c})$. The convex surface of each bi-cylindrical lens must have a focal distance of 10″; the concave surface a negative focal distance of 20″. Having first ascertained, with a simple concave cylindrical lens of $\frac{1}{20}$ $(= - \frac{1}{20}{}^{c})$, the direction of the axis by which vision is most improved, we insert this lens into the spectacle-frame. The lens being held as close as possible to the eye, a simple convex cylindrical lens of $\frac{1}{10}$ $(= \frac{1}{10}{}^{c})$ is rotated close in front of the first lens, to ascertain the position of its axis by which vision is most improved.

The same experiment should be repeated by the optician before fixing the bi-cylindrical lenses in the spectacle frame.

In eyes with abnormal refraction (see Myopia and Hypermetropia) it is often desirable to bring the furthest point of distinct vision to a certain distance only, in other words, to make the eyes to a certain degree short-sighted.

This is accomplished by first ascertaining the refraction in the two

chief meridians of the cornea, and then by deducting from each the desired degree of myopia. Suppose we have simple myopic astigmatism of $\frac{1}{10}$ in the horizontal meridian of the cornea, and we wish to make the patient see distinctly at 20″ and not further. In the vertical meridian of the cornea, which we suppose not astigmatic, he can see at any distance, and, to reduce his range of vision in that meridian to 20″, we must give him a simple positive cylindrical lens of $\frac{1}{20}$ $(= \frac{1}{20}{}^{c})$. To make him see at 20″ through the horizontal meridian of the cornea, in which there is myopic astigmatism of $\frac{1}{10}$, we give a simple negative cylindrical lens of $(\frac{1}{10} - \frac{1}{20} = \frac{1}{20})$ $\frac{1}{20}$ $(= -\frac{1}{20}{}^{c})$.

In the horizontal meridian we have thus reduced myopia from $\frac{1}{10}$ to $\frac{1}{20}$, and we prescribe spectacles with lenses each being bi-cylindrical $= \frac{1}{20}{}^{c} \ulcorner -\frac{1}{20}{}^{c}$. In a case of simple hypermetropic astigmatism of $\frac{1}{10}$ in the horizontal meridian of the cornea, if we wish, as in the first case, to bring the furthest point of distinct vision to 20″, we prescribe for the vertical meridian a simple positive cylindrical lens of $\frac{1}{20}$ $(= \frac{1}{20}{}^{c})$, and for the horizontal meridian one of $(\frac{1}{10} + \frac{1}{20} = \frac{3}{20} = \frac{1}{6\frac{2}{3}})$ $\frac{1}{6\frac{2}{3}}$ $(= \frac{1}{6\frac{2}{3}}{}^{c})$. Instead of a positive bi-cylindrical lens, we may give a positive spherico-cylindrical lens, the spherical surface having a focal distance of 20″, the cylindrical surface one of 10″. We should in all cases give the preference to spherico-cylindrical lenses.

In cases of compound and of mixed astigmatism, we proceed as in those of simple astigmatism, by deducting the myopia, which we wish to produce in each of the chief meridians, from the refraction existing in these meridians. The lenses obtained for each of the two chief meridians are combined into one by prescribing spectacles either with spherico-cylindrical or with bi-cylindrical lenses.

Suppose we find in one meridian a myopia of $\frac{1}{20}$, and we wish to produce a myopia of $\frac{1}{20}$, i. e. to bring the furthest point of distinct vision to 20″, we need not give a lens for that meridian, since the furthest point of distinct vision already lies at 20″. If in the other meridian we find a myopia of $\frac{1}{15}$, we can bring the furthest point of distinct vision to 20″, i. e. change the myopia of $\frac{1}{15}$ into one of $\frac{1}{20}$, by giving a simple negative cylindrical lens of $(\frac{1}{15} - \frac{1}{20} =$ of $\frac{1}{60} = (-\frac{1}{60}{}^{c})$.

If in one of the chief meridians we find a myopia of $\frac{1}{20}$, and in the other a hypermetropia of $\frac{1}{10}$, and we wish to bring the furthest point of distinct vision to 15″, we have to deduct $\frac{1}{15}$ from $\frac{1}{20}$ $(\frac{1}{20} - \frac{1}{15} = -\frac{1}{60})$, and from $\frac{1}{10}$ $(\frac{1}{10} - \frac{1}{15} = \frac{1}{6})$.

Now, in the chief meridian, where there is a myopia of $\frac{1}{20}$, to bring the furthest point of distinct vision to 15″, we have to increase the myopia to one of $\frac{1}{15}$, by giving a simple positive cylindrical lens of $\frac{1}{60}$. In the

other chief meridian where there is a hypermetropia of $\frac{1}{10}$, we bring the furthest point of distinct vision to 15″, by giving a simple positive cylindrical lens of $\frac{1}{6}$.

In the above case we therefore prescribe spectacles with bi-cylindrical lenses, the focal distance of one surface of each lens being 6″, that of the other surface 60″.

CONICAL CORNEA.

(*Staphyloma corneæ pellucidum; Keratoconus; Hyperkeratosis*).

The alteration of curvature termed conical cornea, if far advanced, is readily recognized by a peculiar sparkling reflection from the central portion. If viewed with the ophthalmoscope, a dark shadow is observed on that side of the conical cornea which lies opposite the direction from which the light is thrown upon the cornea. This shadow, situated in front of the "red shining" dilated pupil, is ill-defined, and shifts round the sides of the cone when the eye, under observation, moves in various directions, the observer keeping unaltered the direction in which the light is thrown into the eye.

Slight degrees can only be discovered with the ophthalmoscope. The optic disc, viewed through the apex of the cone, appears extremely small; and seen through the sides, it seems more or less distorted and ill-defined, in consequence of the rays of light coming from the disc having to pass through abnormally curved portions of cornea.

The apex of the cone is at, or near, the centre of the cornea. It is very rarely opaque in slight, but frequently so in extreme cases. If very prominent, the entire cone may become opaque.

Minute examination of the opaque cone and of the adjoining cornea has shown that the healthy cornea gradually merges into the conical portion, which latter decreases in thickness from its base towards its apex. The epithelium and the elastic laminæ appear uninterrupted, the opacity (consisting of elongated nuclei and of a web of nucleated fibres and fusiform cells) being situated between the laminæ.

Vision.—Patients at first complain of becoming short-sighted, especially if both corneæ are altered. Objects appear confused, the light "dazzles," gas-light seems split up into numerous little lights, &c.

The differences in the focal distances of different portions of the cornea—that of the cone, e. g., being much shorter compared with other parts—give rise to polyopia. Vision in high degrees may become reduced to mere perception of large objects, though the cone may appear transparent. None of these symptoms are characteristic of conical cornea.

Conical cornea has been observed between the ages of nine and forty, and most frequently in females of delicate health. In a few cases it seemed

hereditary. It occurs generally in both eyes, but varies in degree in the two.

The cause is not known.

It advances gradually, and may remain stationary at any degree, or increase again after a period of inaction. Rupture has never been known to occur, though there is more than ordinary escape of aqueous humour through the cornea.

Treatment.—Among remedies tending to arrest the thinning and bulging of the cornea, the eye-douche with cold water can be recommended, together with generous diet and the avoidance of those occupations which cause "fullness" of the eyes.

Real benefit has been derived from medical, optical, and surgical appliances. Among these are the application of calabar, of stenopæic spectacles, of concave spherical or cylindrical lenses, and combinations of these remedies. Vision for distance and near-work is much improved by these means in patients with regular and slight cones.

The troublesome dazzling and polyopia has, in several cases, been removed by obscuring a portion of the spectacle lens, e. g. that which comes to stand opposite the apex, or the lower half of the cone.

Surgical Treatment.—Repeated tapping of the aqueous chamber, iridectomy, iridesis, and removal of part of the cone, are the operations made use of. None of these effect a complete removal of the cone, and great improvement of vision is only occasionally obtained.

An operation may, however, be recommended if vision is not improved by optical means alone. Before altering the position of the pupil by iridectomy or by iridesis, we should, with the ophthalmoscope, determine, by "direct examination," through which part of the conical cornea the outlines of the optic disc, and of the vessels passing through it, appear most distinct and least altered. After this we try, with stenopæic remedies, and with and without lenses, whether vision is improved when the patient looks through that portion of the conical cornea alone. We also determine the best form of pupil by the same means.

Iridectomy, as far as can be ascertained by the ophthalmoscope and by lateral illumination, is followed by some decrease of the conicity, besides rendering the eye more susceptible to improvement by optical means. Good and lasting results have also been obtained by iridesis.

In a girl admitted into the hospital in 1863, an iridectomy was followed by slight improvement in one eye, the conical cornea of which was transparent. In the other eye the entire cone, and some of the adjoining cornea, appeared opaque. The great prominence of the cone nearly prevented the lids from closing. In this eye abscission of the apex of the cone was performed. The patient, who previous to this operation could only perceive the shadows of objects, can now tell the time on a watch held $\frac{1}{2}'$ from

the eye, and considers this her best eye. This favourable result has been permanent.

The abscission of the cone was in this case performed by passing thin silver wires, at three different points, horizontally through the cornea, midway between the apex and the base of the cone, and in front of the pupil across the anterior chamber. The portion of the cone in front of the wires was removed, and the opening in the cornea united by twisting together the ends of the wires. The latter were extracted on the appearance of chemosis.

Ten weeks after the operation an opacity in the centre of the cornea, with good curvature and transparency of the rest, and with a clear artificial pupil, were obtained.

The opacity, existing before the operation, had greatly diminished, which may have been due partly to slight corneitis which followed the operation, partly to the change of curvature.

Globular Cornea (*Keratoglobus*).

Globular cornea signifies general enlargement of the cornea. The cornea, when viewing it from the side, appears throughout too convex and the aqueous chamber generally enlarged. A proportionate enlargement of the other tunics, and tremulousness of the iris and crystalline lens are usual complications.

This condition is frequently congenital, and exceptionally occurs only in one eye. The cornea is often slightly nebulous. It may remain transparent.

Globular cornea has been observed after changes which induce uniform loss of resistance of the cornea, such as syphilis, corneitis, or pannus.

The patients complain of being short-sighted. They are often highly amblyopic.

On ophthalmoscopic examination we find the optic disc unusually small, with some atrophy of the choroid near it.

The calabar and stenopæic spectacles have rendered good service in a few cases.

STAPHYLOMA.

Staphyloma signifies an anomaly of curvature of the tunics of the eyeball. It has been observed in most portions of the tunics. Of the numerous varieties of staphyloma, those of the cornea and those occupying the place of the cornea are the most frequent.

A protrusion of one of the tunics, e. g. of the posterior elastic lamina of the cornea, or of the iris, or of the retina, &c., through an ulcer or wound, is termed *a hernia or prolapse.*

If coated over with lymph, or if cicatrized and still protruding, it is termed *a staphyloma.*

Among anomalies of curvature of the cornea we distinguish, (1.) *The globular cornea ;* (2.) *The conical cornea ;* (3.) *A staphylomatous condition of an opaque or nebulous cornea caused by inflammatory changes, ulcers, &c.;* (4.) *Staphylomatous cicatrices occupying the place of portions or of the entire cornea, caused by cicatrized prolapse of the iris.*

In the sclerotic we distinguish *the ciliary, the equatorial, and the posterior staphyloma.*

Ciliary staphyloma may occupy any portion of the ciliary region, i. e. of the sclerotic between the margin of the cornea and a line which passes through the ocular insertions of the recti muscles.

Posterior staphyloma generally occupies the region of the yellow spot, or that of the tunics surrounding the optic disc.

(See Globular and Conical Cornea.)

Staphyloma of an opaque or nebulous cornea may be the result of inflammatory changes, ulcers, &c., occurring in the course of inherited syphilis, measles, scarlatina, variola, &c., or following injuries or operations on the cornea.

Syphilitic corneitis and pannus, implicating the entire cornea, may give rise to rapid staphylomatous changes, the whole of the softened corneal tissue yielding to the pressure of the aqueous humour.

Vision in these cases varies according to the degree of opacity, of alteration of curvature of the cornea, and especially of disturbance of the media and of the retina. Some patients, if the opacity is but slight, complain of weakness of sight; others, of being near-sighted; others, of objects appearing distorted. Only distinction of colours or quantitative perception of light may exist, though the staphylomatous cornea may seem but slightly nebulous. (For treatment see Opacities of Cornea).

Staphylomatous opaque tissue—cicatrices—occupying the place of portions of or of the entire cornea, generally originates in the following manner: a portion of cornea having been destroyed by ulceration, suppuration, &c., the iris, after the escape of aqueous humour, comes to lie against the opening in the cornea. The iris undergoes adhesion to the margins of the opening. Granulations, lymph, &c., are thrown out on the exposed surface of the iris, and become changed into more or less opaque tissue.

The rapidity of formation of this opaque tissue, its strength, and the nature of the treatment, influence the formation and size of the staphyloma. The surface of the staphyloma is frequently uneven or sprinkled with portions of pigment. The staphyloma may be extremely thin and nearly transparent in parts. In the latter case it appears black (myokephalon) from the interior of the eye shining through the transparent portion. In other cases the staphyloma is considerably thicker than the cornea. It becomes covered with dry epithelial scales, especially during sleep, if its surface be exposed to the air too long. Beneath the epithelium

we may find connective tissue, or tissue resembling that of the cornea, but most frequently white fibrous tissue intermixed with blood-vessels.

The staphyloma may become inflamed, or ulcerated, or thin portions may burst, and the aqueous humour escape. The staphyloma may temporarily collapse; or the lens, or "vitreous," or both, may escape.

The collapsed tunics may again become distended by fluid. Bleeding from the choroidal veins between the sclerotic and choroid has followed the rupture of the staphyloma in some cases and ophthalmitis in others. The base of the staphyloma passes, either gradually or abruptly, into adjoining cornea or sclerotic. Its posterior surface may be smooth or uneven. At the portions covered by posterior elastic lamina no adhesions of the iris are found. The debris of black or brown pigment on the posterior surface of the staphyloma belong to the distended iris. An instrument, thrust through the staphyloma into the eye, at once enters the posterior aqueous chamber.

The lens, together with its capsule, may be missing; or it may be opaque, or adherent to the staphyloma, or more or less displaced, though not adherent.

Recurrent attacks of ophthalmia or of iritis may occur (from partial adhesions of the margin of the pupil to the staphyloma, or from disturbances caused by displacement, &c., of the lens) with or without sympathetic changes in the fellow eye.

We frequently meet with glaucomatous changes if the staphyloma has appeared some time after "some inflammation of the eye." These, together with the cicatrix in the cornea, produce a degree of impairment of sight which is very much greater than that caused by staphyloma alone. In these cases, if abscission be performed, intraocular hæmorrhage, or suppuration, often follows the operation.

Treatment.—A staphyloma, if left to itself, may remain stationary for years. It may, on the other hand, burst frequently, and occasionally give rise to the changes mentioned above. The rupture relieves the patient temporarily; and many, to obtain ease, soon learn to puncture the thinnest part, or the one they observe giving way spontaneously, and thus for years alleviate the distress caused by the size of the staphyloma.

In recent prolapse of the iris, or in sloughing of portions of cornea, we order a bandage to be applied over the closed eyelids, to prevent the occurrence of staphyloma. The bandage has to be removed repeatedly during the day, and atropia applied to lessen the tension of the eye during cicatrization. An iridectomy, done at this stage, and followed by gentle pressure, will be found of great service.

The eyelids should carefully be kept "bound up" until a firm cicatrix has formed.

Staphyloma of long standing is treated by iridectomy with removal

of the lens, and by abscission of the staphyloma, if part of the cornea is clear and the retina sensitive throughout.

If the walls of the staphyloma appear thin, a good cicatrix may be obtained by first puncturing the staphyloma. The fluid, accumulated behind, is allowed to escape. A vertical incision is then made with scissors through the staphyloma, from apex to base. By properly applied pressure, assisted, if necessary, by a suture, its walls are made to overlap one another, and are left to contract adhesion (the anterior surface of the one part of the staphyloma with the posterior surface of the other). The eyelids are kept "bound up" until all vascularity of the conjunctiva and sclerotic has subsided.

Excision or abscission of the eyeball is indicated, if the staphyloma causes pain or sympathetic irritation of the fellow eye.

The patient, if he wishes the operation performed for reasons of personal appearance, and if there be perception of light with the staphylomatous eye, should be informed of the loss of the perception of light by the operation, and also of the trouble connected with the wearing of an artificial eye.

A better result, as regards appearance, is obtained by abscision. The repeated occurrence of suppuration of previously abscised eyes and of continuance of sympathetic irritation indicate, in poor persons, excision as the quicker and safer treatment.

Abscission should always be performed in staphyloma following purulent ophthalmia.

THE SCLEROTIC.

GENERAL AND ANATOMICAL REMARKS.

The sclerotic is a fibrous capsule with a large opening for the passage of the optic nerve, and with numerous smaller apertures (situated especially some immediately in front of, and some behind, the insertion of the recti-muscles and round the optic nerve) for the blood-vessels and nerves of the choroid. The surface of the sclerotic is slightly grooved (just behind the insertion of the recti-muscles) for the reception of tendons. It is very slightly depressed at the line of junction with the cornea. At this spot is situated *the circular sinus* or *canal of Schlemm.*

The sclerotic moves within a capsule termed "*Tenon's capsule,*" or "*sub-conjunctival fascia,*" which is attached to the margin of the orbit behind the suspensory ligament of the eyelids, and which, further back, merges into the sheath of the optic nerve.

This capsule isolates the eyeball from the soft parts of the orbit. The muscles of the eyeball (loosely attached to this capsule) pass through it to reach the sclerotic. Behind their insertion connective tissue is found between the capsule and the sclerotic.

The sclerotic receives but few blood-vessels and nerves. The subconjunctival tissue in front of the insertion of the recti-muscles is nourished by capillaries, which anastomose with blood-vessels going to the ciliary processes; and therefore over-fulness of the latter, whether chronic or acute, betrays itself by enlargement of vessels upon the sclerotic, near the margin of the cornea.

The sclerotic, otherwise of a dead white colour, appears brilliantly white where it is covered by conjunctiva. The thicker the sclerotic the whiter it appears; the thinner, the more bluish. In dark persons, brown or black pigment spots may be seen in its ciliary portion. In highly myopic persons it often appears bluish (semi-transparent) about the region of the yellow spot. Prolonged congestion of the ciliary veins leads to enlargement of their respective sclerotic apertures.

To become familiar with the shades of colour of the sclerotic, which lie within the limits of health, we should examine the sclerotic of many fair and dark persons.

The colour of the inner (choroidal) surface of the sclerotic can, in fair persons, be readily seen with the ophthalmoscope, while in those of dark complexion (who have a highly pigmented choroid) too little light reaches the sclerotic to render it conspicuous. If the sclerotic is very thin some light passes through it, and the large blood-vessels can be perceived in its substance.

The thickness of a healthy full-grown sclerotic, near the optic nerve, amounts to $\frac{1}{22}''$; a quarter of an inch behind the margin of the cornea to $\frac{1}{38}''$; and immediately behind the insertion of the recti-muscles to $\frac{1}{56}''$. In some cases, when the vitreous is removed, the sclerotic and the adjoining tunics are thrown into folds; in other equally healthy eyes they remain expanded, and retain their curvature, even though all the vitreous may have been removed.

The arrangements and proportions of the different kinds of tissue of which the sclerotic is composed vary in different parts, especially along the margin of the cornea, at the optic nerve, at the region of the yellow spot, and round the apertures for the choroidal nerves and blood-vessels.

The sclerotic, generally speaking, consists of an interlacement of white fibrous tissue, with broad bands of connective tissue interwoven with yellow elastic fibres.

DEVELOPMENT.

Before the third month of fœtal life no difference of appearance is

observed between cornea and sclerotic. Both are almost transparent and extremely thin. A circular prominent fold appears as the first indication of a boundary between cornea and sclerotic. The part encircled by the fold becomes the cornea. The small round transparent globules of which, at that period, the sclerotic consists microscopically, become intermixed with fibrillæ. About the middle of the third month the cornea, for a short time, becomes opaque, but soon resumes its transparency, while the sclerotic remains opaque, its inner surface presenting a silvery lustre.

About the middle of the third month, when the sclerotic protuberance is perceptible, a thick network of blood-vessels appears upon the outer surface of the sclerotic, close behind the insertion of the recti-muscles; it forms a kind of circle round the eyeball, and gradually extends towards the cornea and towards the optic nerve. These blood-vessels assist in the formation of the greater portion of the fibrous structure of the sclerotic.

The sclerotic rapidly increases in thickness and density about the middle of the fifth month. About this time the fœtal changes of shape of the eyeball and the closure of the fœtal fissure are completed.

CONGENITAL ANOMALIES.

A double sclerotic, the rudiments of a second being situated within an entire one, has been observed. Bluish spots in the sclerotic, or a general bluish (semi-transparent) tint, due to great thinness, are frequently observed in infants. Remnants of the sclerotic protuberance have occurred in microphthalmic eyes.

Prominences beyond the general curvature are not uncommon round the insertion of the recti-muscles, or round the optic nerve.

TUMOURS.

Little "*dermoid tumours*" are generally congenital. At their bases they are adherent to the sclerotic, and at their summits to the conjunctiva. Hairs are often found projecting from their surfaces. They are easily removed. (See Tumours of Conjunctiva, and of Cornea.)

Staphyloma, especially in the ciliary region; "strumous deposit" in the same region; medullary and especially melanotic cancer (often found upon the equatorial part of the sclerotic), have been mistaken for tumours of the sclerotic itself.

INFLAMMATION.

The sclerotic is frequently involved in inflammation of adjoining tunics, e. g. of the conjunctiva, or of the ciliary processes.

Circumscribed inflammation of the sclerotic, together with that of the subconjunctival fascia and conjunctiva, is mostly of syphilitic origin. The inflammation commences in the sclerotic, and frequently in its

ciliary region, where it forms patches of a purple tint, covered with larger vessels. The vascular sclerotic and the subconjunctival tissue appear swollen. The inflammation subsides spontaneously after from five to ten weeks, leaving the sclerotic slightly discoloured, semitransparent, and thinner. Attacks of circumscribed inflammation often appear successively in adjoining parts of the ciliary region of the sclerotic.

Treatment.—The circumscribed inflammation readily subsides under the use of bi-chloride of mercury (from $\frac{1}{24}$ to $\frac{1}{16}$ of a grain to be taken twice daily in some water), and the local application of atropia (a few drops of the solution "to be dropped into the eye" twice daily). The same treatment is adopted if a new attack appears, which often happens at the same season of several succeeding years. If this treatment should not succeed, syndectomy can be recommended.

RHEUMATIC INFLAMMATION OF THE SCLEROTIC.

In rare cases we meet with an acute diffused purple redness and slight swelling of the sclerotic, with extreme intolerance of light and great pain, brought on by exposure to cold.

When minutely examining a section of such a sclerotic, we find in the inflamed portion groups of what appear to be connective tissue corpuscles. The latter are swollen, and their stellate processes anastomose with each other and with those of neighbouring groups. Their granules change into cells, and, probably by sub-division, increase in number. The substance, intervening between the nests of corpuscles, gradually disappears, or, if the inflammation is very acute, is changed into a yellowish pulpy substance ("slough"), while the nuclei and cells of the connective tissue corpuscles undergo fatty degeneration.

Treatment.—The frequent application of pieces of lint, dipped into hot Lotio Papaveris, and of chloroform liniment, to the skin of the eyelids, forehead, and temple, are prescribed, together with frequent instillations of atropia. The eyes must be kept excluded from light.

The general medical treatment depends upon the state of health of the patient.

INFLAMMATION OF TENON'S CAPSULE.

This form of "sclerotic" inflammation is a common occurrence in the course of ophthalmitis. The subconjunctival fascia becomes adherent to the sclerotic, &c.

Inflammation of circumscribed portions of the subconjunctival fascia has been observed in myopia, in tumours of the orbit or eyeball, and occasionally after exposure to cold. The inflammation is accompanied by slight ptosis, and by a sensation of tension in the eyeball. Sometimes there is

severe pain in and round the orbit, with vascularity and serous chemosis of the conjunctiva. The eyeball is slightly protruding, and its movements are slow and painful.

Treatment.—Cold fomentations, or the local application of ice, should be tried first, with a number of leeches (proportionate to the strength of the patient) applied to the skin of the corresponding temple. Fomentations with warm or hot Lot. Papaveris, are ordered if the cold should be unpleasant to the patient. If ophthalmitis, or intra-ocular tumour, should be the cause, excision of the eye may become necessary.

ULCERATION OF THE SCLEROTIC.

An ulcer of the sclerotic is preceded by yellowish-grey, opaque, and circumscribed infiltration of the sclerotic. The margins of the ulcer are abrupt, the base yellowish-white and opaque. This is accompanied by much redness and swelling of the surrounding sclerotic and conjunctiva.

A patient, who some months ago left the hospital after recovery from a syphilitic ulcer of the lower lid, lately presented himself with two deep ulcers in the lower and outer part of the sclerotic, with ulceration of the cornea, and with some iritis. The ulcers healed rapidly under the application of the Ungt. Hydrarg. Nitrat. Mitius. A quantity of the size of a small pea was rubbed into the ulcers twice daily.

Cancerous ulcerations of the eyelids may encroach upon the sclerotic.

STAPHYLOMA OF THE SCLEROTIC.

(See also Staphyloma of the Cornea.)

In Staphyloma the sclerotic is not the only tunic which is altered. The staphylomatous condition, as a rule, extends to the deeper tunics, e. g. in posterior staphyloma the choroid, retina, optic disc, and vitreous substance are simultaneously implicated. The portions of the sclerotic which correspond to the ciliary processes—those round the optic nerve, especially over the yellow spot—and those at the equatorial part of the eyeball—become frequently staphylomatous.

We thus distinguish the *Ciliary Staphyloma*, the *Posterior Staphyloma*, and the *Equatorial Staphyloma.*

The entire ciliary region may be altered in curvature; or the entire sclerotic may be changed in shape and cause protrusion of the eyeball. A large staphyloma in the region of the yellow spot may exist without giving rise to protrusion of the eyeball, but generally impairs its mobility.

The spots of sclerotic, through which choroidal veins pass, become frequently staphylomatous in the course of chronic morbid changes, accompanied by increase of tension.

The size, shape, and colour of the staphyloma vary. Small ciliary staphylomata appear as bluish, bulging, smooth spots or streaks, alternating with more healthy (white) portions of the sclerotic, and radiating from near the margin of the cornea. The staphylomata, which formerly were supposed to be varicose veins of the choroid, are atrophic portions of the tunics of the ciliary region separated from each other by more healthy parts. Ciliary staphylomata lead to displacement of the cornea, and with it to alteration of the distance between the insertion of one, or of several, of the recti-muscles, and the margin of the cornea.

The equatorial staphyloma is frequently observed behind, or at the side of, the sclerotic insertion of the superior rectus-muscle. It has been mistaken for intraocular tumour, of which, however, it may be a complication.

In the discovery of the morbid changes which accompany staphyloma of the sclerotic we are assisted by the ophthalmoscope, by light concentrated upon the tunics by means of a strong convex lens, and by ascertaining the tension of the eye and the function of the ciliary nerves (the sensibility of different parts of the cornea).

The tunics are adherent to each other, and most altered at and near the most prominent part of the staphyloma. On minute examination frequently no vessels or nerves are found. Of the retina, if implicated, only the fibres of the framework, forming large irregular meshes, may be left. In less staphylomatous portions of the retina only the ganglion cells may be missing.

The choroidal pigment (stellate pigment cells) is generally destroyed, or appears very pale. The hexagonal cells are either absent, or have lost their characteristic shape. Their pigment granules may be present. Their place is occasionally found occupied by transparent globules.

Severe pain, intolerance of light, and fiery circles, trouble the patient while the equatorial staphyloma is increasing rapidly.

Its progress is however generally slow, and sometimes accompanied by intermittent dull pain, and by attacks of "ophthalmia."

Vision varies according to the locality and complications of the staphyloma.

Large ciliary or posterior staphylomata admit of excellent sight, while with equatorial staphylomata there may be none, or bare perception of light.

Causes.

Injuries.—A blow may rupture the choroid and retina and leave the sclerotic intact, and some time after may be followed by staphyloma of the corresponding portion of the sclerotic. Sclerotic staphylomata from injury occurs more frequently in the ciliary region. Loss of substance of

the sclerotic, from wounds or ulcers, may be followed by staphyloma, not only of the cicatrix, but also of some of the adjoining sclerotic.

Inflammation of several or of all the tunics, mostly of syphilitic origin. Circumscribed portions of the ciliary region are often successively involved; portions of conjunctiva, subconjunctival tissue, and sclerotic, appearing vascular and swollen and gradually becoming staphylomatous.

For posterior staphyloma, see Myopia, Coloboma, and Development of the various tunics.

Treatment.

Attacks of inflammation or pain, caused by the staphyloma, or the wish to obviate or remove sympathetic irritation of the fellow eye, or the improvement of personal appearance, may render an operation necessary.

Excision of the eye is the quickest and safest treatment, and should be recommended to poor persons, where the loss of time is of consequence. Iridectomy should previously be tried, if the external appearance of the eye is satisfactory. Abscission succeeds best in sclerotic staphyloma following purulent ophthalmia. The removal of iris and lens has, in some cases, been attended with good result.

The observation that suppuration of the vitreous substance and choroid leads to shrinking of the eyeball, has led to the treatment of drawing a silk thread through the tunics of the eye, and through the vitreous chamber. The silk thread is inserted a little behind the insertion of the inner and outer recti-muscles, and is left until well-marked chemosis is produced, when it is withdrawn. The eye gradually shrinks, and, as in abscission, admits of the insertion of an artificial eye of more natural appearance.

INJURIES.

Clean cuts or punctures of the sclerotic heal readily with the formation of a semitransparent cicatrix. The lids of the eye, thus wounded, should be closed, wet lint being kept tied over them until the wound in the sclerotic has healed, and all undue vascularity disappeared. The fellow eye, if there be no sympathetic irritation, may be used for work.

Rupture of the sclerotic, from blows, &c., occurs most frequently near the upper or inner margin of the cornea. The eyeball, being least protected at the outer and lower border of the orbit, is driven by the blow against the opposite prominent orbital margin. The rupture is often complicated with bleeding into the anterior chamber, with separation of part or of the entire iris from its line of insertion, and with dislocation of the lens, the latter escaping through the wound. Portions of iris, choroid, vitreous, or retina, may project through the wound. All the contents of the sclerotic may escape, the latter becoming filled with blood.

Treatment.—The prognosis depends, in greater part, upon the amount of injury inflicted upon the deeper structures of the eye. After having cleaned the wound from extraneous substances, portions of vitreous, &c., lint, dipped into fresh water, is applied over the closed lids of the injured eye; upon this some cotton wool is placed, and the whole secured by a bandage. The lint must be kept moist, and the bandage renewed occasionally. Rest of the injured eye, and instillations of atropia into the fellow eye, if any sympathetic irritation exists, are prescribed. In the absence of all irritation, the uninjured eye may be used for work. (See Injuries of Choroid, Retina, &c.)

CHAPTER VII.

THE EYEBALL.

TENSION. SHAPE. REFRACTION. ACCOMMODATION. EXAMINATION WITH THE OPHTHALMOSCOPE. SPECTACLES. ANOMALIES OF REFRACTION. HYPERMETROPIA. MYOPIA.

TENSION OF THE EYEBALL.

The resistance which we feel, (or the depression which we see,) when pressing upon the eyeball in its equatorial region, is termed the tension (= T) of the eyeball.

The tension of healthy eyes varies but slightly, though some difference may be observed in the degree of tension even at different times of the day.

The normal degree of tension we express by the sign T.nl., while the signs T+? and T—? indicate a doubt as to whether the tension is abnormally increased or diminished. T + 1, T + 2, T + 3, all indicate increase of T. T + 3 represents the highest degree of increased tension, in which the eyeball can no longer be "dimpled" by pressure with the fingers.

T — 1, T — 2, T — 3, all indicate an abnormal decrease of tension. The numbers 1, 2, 3 are arbitrary.

Increase of tension is one of the characteristics of glaucoma.

Increased tension has been observed—in the course of traumatic cataract, — of iritis and choroido-iritis, — after extraction of cataract, — in myopia with amblyopia, &c., &c.

A decrease of tension is observed when the vessels in the ciliary processes are obliterated by lymph, &c., or after long-continued or extensive choroido-iritis, especially of the syphilitic form.

We ascertain the tension of the eyeball either by touch, or by sight.

By touch.—The eyelids being closed gently, we rest one forefinger upon that spot of the skin of the eyelids which corresponds to the outer margin of the superior rectus-muscle, near its sclerotic insertion, and place the other forefinger upon a corresponding spot near its inner margin.

By gently pressing upon the skin and eyeball with one forefinger (as when examining for fluctuation of an abscess), we feel the tunics of the eye yield, more or less readily, to the pressure; while the spot upon which the other forefinger rests is somewhat raised.

The degree of readiness with which the tunics yield to pressure indicates the degree of tension of the eyeball.

By sight.—Directing the patient to look upwards, we gently press the inner edge of the margin of the lower lid upon the sclerotic. By this pressure the curvature of the sclerotic and that of the other tunics becomes altered, the latter being pressed towards the elastic contents of the vitreous chamber. The amount of flattening, or indentation of the tunics, thus produced, indicates the degree of tension. This pressure, in hard eyes, instead of producing any visible indentation, causes displacement of the entire eyeball.

The pressure which the blood exercises on the walls of the blood-vessels in the eye is greater than the pressure of the vitreous substance and of the tunics of the eyeball upon the same blood-vessels, since a considerable pressure upon the tunics is required before the blood is prevented from passing through the blood-vessels in the optic disc. A pressure which is sufficient to prevent the blood from passing into the arteries in the optic disc may be considered as almost equal to the pressure which the blood exercises upon the walls of the retinal arteries.

A study of the effect of artificial pressure (by pressing upon the eyeball while viewing the optic disc with the ophthalmoscope) upon the circulation in the blood-vessels which pass through the optic disc should not be neglected.

Slight pressure increases the pulsation of the retinal veins. Somewhat greater pressure causes pulsation of the retinal arteries (in the optic disc). The blood suddenly fills the arteries during the systole; during the diastole they appear empty, while the veins (in the optic disc) appear either empty, or, if pulsating, coincide in their dilatation with the contraction of the arteries. Considerable and continuous external pressure causes simultaneous dilatation of the arteries and veins in the retina, while the optic disc appears white (anæmic), all the blood having been displaced from its vessels. The effects of pressure, if continuous, differ somewhat. The retinal blood-vessels appear momentarily much enlarged on sudden removal of moderate and continuous pressure; probably through a diminution having occurred in the contents of the vitreous chamber, the blood temporarily making up for the loss.

The pressure of the blood, which circulates in the eye, upon the walls of the blood-vessels, and the pressure of the tunics of the eyeball and of the vitreous substance upon the blood-vessels, are in health so evenly balanced that the circulation is not interrupted. It has been observed that complete

interruption of the return of the venous blood from the head does not increase the tension of the eyeball.

The facts that very slight pressure upon the eyeball causes disturbance in the circulation in the optic disc,—that the veins are frequently found filled with blood in recently excised healthy eyes,—and that, on removing circumscribed portions of sclerotic and choroid, there is but very slight bulging of the corresponding retina and vitreous substance or none at all —seem to prove that, under normal circumstances, there is, if any, at all events not sufficient pressure from the contents of the eyeball upon the blood in its vessels to interrupt the circulation.

During morbid changes, accompanied by diminution of tension, the retinal arteries are abnormally dilated; and from this fact it is supposed that the pressure, which the blood exercises upon the coats of the arteries, would cause the latter to appear more dilated under normal circumstances, but for the vitreous substance exercising some pressure on them. The balance between the pressure exercised by the blood upon its vessels in the choroid and retina, and between the pressure upon these vessels and the blood by the vitreous substance and the tunics of the eyeball, may be disturbed by a sudden increase or decrease of the density of the vitreous substance,—by changes in the pressure of the blood,—by an impeded return of blood from the interior of the eye,—by pressure from without, &c.

Division of the fifth nerve, or of its ophthalmic division, is followed by increased tension of the eyeball, as long as the pupil is contracted and the iris close to the cornea. This, if the eye is kept closed and not exposed to irritation, is succeeded by decrease of tension.

The prolonged contact of the iris with the cornea, and the pressure of the crystalline lens upon the iris or upon the ciliary processes, are especially apt to give rise to increased tension.

Changes of the pressure, under which the blood, and through it the walls of the blood-vessels stand, may be recognized by alterations in the appearance of the blood-vessels of the retina, especially of those in the optic disc, and by changes in the tension of the eyeball. The greater the dilatation of the arteries the less is the pressure of the vitreous substance; the narrower the arteries the greater is this pressure.

The greater the pressure of the vitreous upon the blood and the vessels in the retina the slower is the circulation in the veins; the more dilated, varicose, &c., these appear the greater is the impediment to the escape of blood where the veins pass through the optic disc. (See Glaucoma.)

SHAPE OF THE EYEBALL.

The eyelids in great part mask the shape of the eyeball.

To obtain an idea of the shape, we must draw the outer canthus and the corresponding part of the fornix of the conjunctiva away from the eyeball,

and direct the patient to turn the eye as much as possible in the opposite direction. The curvature of the sclerotic, from the outer margin of the cornea to near the optic nerve, is thus brought into view. From the more or less acute curvature of that part we obtain an idea of the length and general shape of the eyeball, and, to some extent, of the distance of the retina (yellow spot) from the crystalline lens.

The more acute this curvature is the shorter (the more hypermetropic), and the more gradual the curvature is the longer (the more myopic), do we suppose the eyeball to be.

With some practice we can readily distinguish the myopic or elongated, the hypermetropic or short, and the emmetropic or normal shaped eye.

By raising the upper or depressing the lower eyelid, and directing the patient to look in different directions, we ascertain the curvature of the other parts of the sclerotic.

For the mode of ascertaining the shape of the eyeball with the ophthalmoscope, see Examination with the Ophthalmoscope, Examination of the erect image, &c.

DEVELOPMENT OF THE EYEBALL.

The skin of the face, at an early period of fœtal life, consists of one layer of cells, which lie side by side.

The cells, occupying the future position of the eyeballs, become afterwards bulged forward by fluid of the adjoining brain-cell.

The eyelids, conjunctiva, sclerotic, cornea, crystalline lens, and the vitreous substance are developed out of this layer of cells; while the retina, and probably also the choroid, are connected with the development of the brain-cell.

A bluish, dark, ill-defined line forming an arc, (at first not perceptible to the unaided eye,) represents the first trace of the eyeball.

About the fourth week the eyeballs lie very close to each other, appearing as oval elevations of the colour of the surrounding skin.

These become more and more prominent, larger, and of a dark, bluish colour. Some of the cells occupying the place of the cornea become bulged towards the interior of the eye, and form the commencement of the crystalline lens. A similar bulging mass of cells, appearing beneath the first and pushing itself in between the retina and the crystalline lens, becomes the vitreous substance.

The left eye is frequently the more advanced in development.

The eyeball undergoes various changes of shape during fœtal life. At a very early period it has round the optic nerve a somewhat angular shape. Its transverse diameter, for a considerable time, exceeds the antero-posterior; thus the eyeball appears flattened from before backwards. Through greater prominence of the cornea and of the tunics in the region of the

yellow spot, it becomes more oblong about the end of the third month. (See Fœtal Fissure.)

CONGENITAL ANOMALIES.

Absence of both eyes (anophthalmos) with absence of the orbits, and absence of one eye, the other being healthy (monophthalmos), have been observed.

A woman, during the fourth month of pregnancy, was frightened by a dog with only one eye. She gave birth to a full-grown child without eyeballs and without eyelashes. The lids were adherent to each other, and a reddish line marked the boundary between the upper and lower lid. An immoveable reddish mass of cellular tissue filled the orbit. The child grew up well. Those born subsequently had normal eyes.

Malposition of the eyes, one standing higher than the other, or one being deeper seated or more protruding; both being too near together (sometimes with absence of one or of several of the bones of the orbit) or both being more or less completely united into one eyeball (cyclopic eye) have been observed; also supernumerary eyes, e.g. one head with three or four eyes, or two heads with three or four eyes.

Among anomalies of shape we observe the too large eyeball (Megalo, or Buphophthalmos), and the too small eyeball (Microphthalmos). The former may occur, as the result of choroido-iritis, confined to one eye.

An extension of the tunics, especially in the region of the yellow spot, is the characteristic attribute of the myopic eye.

Microphthalmos is more common in females, and occurs generally in both eyes; if only in one, it is the right which as a rule is affected. Several children of the same family may suffer from it, though the abnormal tendency seems to exhaust itself in time, e.g. the first two or three children may be microphthalmic, while all those born subsequently have normally-shaped eyes.

We distinguish the microphthalmos caused by disease during fœtal life from that which is due to arrest of development. The latter form is frequently complicated with hydrocephalus, with stumpy, notched, "rocky," or otherwise deformed teeth, with coloboma, absence of the iris, and with so-called congenital cataract. All parts of the eye, though present, may have been arrested in growth. As causes on the part of the parents have been mentioned—syphilis,—the abuse of alcoholic drinks,—and frights during pregnancy.

Tolerably good vision is compatible with even a high degree of microphthalmos. Vision in these cases should be perseveringly practised, since it is susceptible of much improvement.

Highly hypermetropic eyes are conspicuous from their small globular shape.

THE EYEBALL CONSIDERED AS AN OPTICAL INSTRUMENT.

Each eyeball is suspended within its orbit between two forces—the recti muscles and the oblique muscles. The fat and fibrous tissue of the orbit are most considerable inwards and below. The eyeball gravitates most in this direction.

The shape of the eyeball is spherical. We distinguish in it an anterior and a posterior pole; the former occupies the apex of the cornea, the latter the point of the outer surface of the sclerotic which lies nearest the centre of the yellow spot. An imaginary line, drawn from pole to pole, is termed the axis of the eyeball. This line must not be mistaken for the visual line (by some termed the visual axis), which is an imaginary straight line drawn from the centre of the yellow spot to the point of an object "directly" looked at. The visual line does not pass through the apex of the cornea.

The equator is an imaginary line drawn round the eyeball, and equidistant from the poles. It divides the eyeball into anterior and posterior halves. In the anterior half we have the cornea and the ciliary region; in the posterior the region of the yellow spot and the region of the optic nerve. The part at and near the equator is termed the equatorial region.

Meridians are semi-circles extending along the curvature of the eyeball from pole to pole. We particularly distinguish two principal or chief meridians,—the vertical and the horizontal meridian of the eyeball, of the cornea, &c.

Modern researches on the functions of those parts of the eye which are engaged in the refraction of light and in accommodation, have given rise to the introduction of new, and to the alteration of the meaning of already existing, technical terms. The knowledge of some of these is essential to enable the medical man more readily to understand the phraseology adopted to express the functions, &c., of the different parts of the eyeball as an optical instrument in general, and to read with benefit the modern books published on the subject.

The light-refracting parts of the eye are termed *the dioptric system.* These are chiefly the cornea and the crystalline lens. Where the term dioptric system occurs the cornea and crystalline lens are to be understood, e.g. if it is stated that the retina (its yellow spot) is placed at the focal distance of the dioptric system, this signifies that the distance from the cornea and crystalline lens is such, that parallel rays passing through the cornea, aqueous chamber, pupil, crystalline lens, and vitreous chamber, are brought to a focus in the retina.

The dioptric system is compound, i.e. it consists of various light-refracting surfaces. These are:—

(*a.*) The anterior surface of the cornea. Its curvature or convexity is such that parallel rays would come to a focus far behind the retina, but for the presence of the crystalline lens.

(*b.*) The anterior surface of the crystalline lens. We must distinguish between its curvature when at rest, i. e. not under the influence of accommodation, and between the increased curvature which it assumes when the power of accommodation is active.

(*c.*) The posterior surface of the crystalline lens (the anterior surface of the hyaloid fossa).

To facilitate our recollecting the alterations which the rays of light undergo in their course through the dioptric system, that system may be assumed as consisting of one single refracting surface. Instead of the refraction being effected by the cornea and crystalline lens, we will suppose the cornea only to be present, but to have such curvature as will alter the course of the rays of light, as if both the cornea and crystalline lens were present. Such a cornea must therefore be more convex, and it has been found that it must have a radius of curvature of ·19685 in.; in other words, that a right line (the radius of curvature) drawn from the centre of the refracting surface to any point of that surface must have a length of ·19685 in., instead of ·31496 in., which is the radius of curvature of the cornea.

In this system of refraction certain fixed points, termed cardinal points, have been determined. The cardinal points are situated in the axis, i.e. in the imaginary right line drawn through the centre of curvature of the light-refracting surfaces. They are:—

(1.) The posterior focus (expressed by ϕ'') of the dioptric system. This is the focus for rays which, outside the eye, run parallel with the axis of the system; it is situated in the retina, if the refraction of the eye is normal.

The point at which the axis cuts the cornea is termed the principal point (= h). The distance from h to ϕ'' is termed the posterior focal distance ($=F_{''}$) and amounts to ·07864 in.

(2.) Rays which return from the interior of the eye, and which in the vitreous chamber run parallel with the axis of the dioptric system, are brought to a focus in front of the dioptric system. This focus ($= \phi_{,}$) is termed the anterior focus, and its distance from the principal point (h) =·59056 in.; the distance from h to $\phi_{,}$ is termed the anterior focal distance of the dioptric system ($h\phi_{,} = F = $ ·5905 in.).

The centre of curvature of the refracting surface is termed the optical centre, or *nodal point.* This point, in the normal (emmetropic) eye, lies about $\frac{1}{4}''$ behind the anterior surface of the cornea, and about $\frac{3}{5}''$ from the yellow spot (retina).

An imaginary right line, drawn from any point of a distinctly-seen

object through the nodal point to a corresponding point of the image of the object in the retina, is termed a line of direction.

The lines of direction meet in the nodal point, and rays which outside the eye are directed to this point, continue their course in the eye in a direction parallel to the one they had outside the eye.

When stating the distances of objects (of spectacles, lenses, test types, &c.) *from the eye,* e.g. that objects, letters, &c., can be recognized at 4, 6, 10, &c., inches, or at 4, 6; 10, &c., feet from the eye, it is from *the nodal point* that these distances are measured. An object which is stated as being situated at 5′, 10′, &c., from the eye, lies at a distance of 5′, 10′, &c., not from the retina, nor from the cornea, but from the nodal point.

THE REFRACTION OF THE EYE.

The retina and cornea are curved surfaces which, as research has shown, alter neither their curvature nor their distance from each other during the act of vision. Let us suppose the same to be the case with the crystalline lens, as e.g. occurs when the power of accommodation (the ciliary muscle) is paralysed. We then have an optical instrument, in which, in the normal (emmetropic) eye, the retina is placed at the principal focal distance of the cornea and lens. The cornea and lens (= the dioptric system) therefore bring to a focus in the retina those rays which, outside the eye, are parallel with the axis of the dioptric system.

This is the case only with the rays which come from objects which lie at a great distance from the eyes.

If an object is brought nearer the eyes the rays emanating from it become more divergent, and the more so the nearer the object approaches. The cornea, crystalline lens, and retina occupying, as was assumed, fixed positions, and their surfaces remaining unaltered in curvature, the more diverging rays are brought to a focus not in, but behind the retina, and the farther behind, the nearer the object approaches. The refractive power of the eye no longer suffices to bring divergent rays to a focus in the retina. An increase of the refractive power becomes necessary, which is effected by the act of accommodation.

The refraction is normal, and the eye termed an *emmetropic eye,* if rays, which outside the eye are parallel with the axis of the dioptric system or nearly so, are brought to a focus in the retina, without any alteration of curvature of the light-refracting surfaces being required.

The refraction is abnormal, and the eye is termed *ametropic,* if the retina does not lie at the focal distance of the dioptric system, assuming that system to be at rest, i. e. the curvature of its surfaces unaltered. The two different anomalies frequently occur; either the retina lies too far from the dioptric system (such an eye is termed myopic or short-sighted), or it lies too near the dioptric system. It is then termed a hypermetropic eye.

Occasionally it happens that the curvature of the cornea is abnormal, and that the focal distance of the dioptric system becomes thus altered, though the retina occupy its normal position. In rare cases we find together with abnormal curvature of the cornea, an alteration in the position of the retina.

MODE OF ASCERTAINING THE REFRACTION OF THE EYE.

Only parallel or nearly parallel rays, i. e. rays coming from distant objects, can, without making use of accommodation, be brought to a focus in the retina by the emmetropic eye. It is, therefore, necessary to place the objects, which we may wish to use for testing the refraction, at a great distance. For this purpose test-types are generally used.

Letters of XX. of Snellen's test-types are placed at 20 feet (20′) from the eye, the refraction of which we wish to ascertain. The rays coming from the letters, when placed at that distance, are supposed to be parallel, or nearly so. The letters are placed about level with, and opposite to, the eye under examination.

Convergence of the eyes is necessarily accompanied by accommodation, and should therefore be avoided. The hand, or some opaque object, is placed close in front of the eye which is not under examination. If the eye under examination recognizes the letters of XX. at 20′, and if, by holding close in front of it a weak convex or concave spherical lens (e. g. of 80-inch focus), vision is less acute, we assume the refraction of the eye to be normal, i. e. to be such that parallel rays are brought to a focus in the retina by the refracting power of the dioptric system of the eye alone, without any effort of accommodation being made. The eye, which recognizes distinctly letters of XX. at 20′, of XXX. at 30′, and whose vision is not improved either by negative or by positive spherical lenses, is termed an emmetropic eye, with normal acuteness of vision ($=$ V or S $= 1$). The farthest point of distinct vision ($=$ r) lies at infinite distance (r $= \infty$) and R, which expresses the distance of r from the eye, $= \frac{1}{\infty}$.

If the eye under examination can read letters of XX. not at 20′ but only at 10′, it does not necessarily follow that the acuteness of vision is impaired, i. e. that the eye is amblyopic.

The eye may be merely myopic. We try concave and convex lenses. If concave lenses improve vision so that letters of XX. can now be read at 20′, we infer that the refraction of the eye alone is disturbed, and not the function of the retina, and that the eye is myopic. See Myopia.

If concave lenses improve vision so that letters of XX. can be read at 15′, but not at 20′, then the eye is still myopic, but there is also amblyopia; in other words, vision is not only impaired through anomalous refraction, but also through morbid changes in the retina, &c. (See Myopia.)

If the eye under examination can distinguish the letters of xx at 20′ without the aid of lenses, and can do the same with convex lenses, the eye is termed hypermetropic; and the stronger the convex lens is with which the letters of xx can still be recognized at 20′, the higher is the degree of the hypermetropia. (See Hypermetropia.)

Hypermetropic, like myopic, persons are often amblyopic.

Those familiar with the direct mode of examination with the ophthalmoscope can, in most instances, and with the greatest quickness, ascertain the refraction of an eye, and, with some exercise, even the average degree. (See Examination with the Ophthalmoscope.)

Whether, as age advances, the refraction becomes altered through changes in the cornea, is not decided.

In many persons about the age of 60 or 70 the crystalline lens becomes hard throughout, and its refraction diminished, so that the eye becomes hypermetropic, the focus of the lens at rest coming to lie behind the retina.

Connected with anomalies of refraction are numerous structural changes in the eye, and peculiarities in other parts of the body. The first thing which should be ascertained in every case of impaired vision, is the refraction of each eye individually. The state of refraction furnishes the key to the treatment, the prognosis, &c., of by far the larger number of cases of impaired vision.

Having determined the refraction of an eye, i. e. the farthest point of distinct vision, we ascertain the state of its accommodation, and with it the nearest point of distinct vision.

THE ACCOMMODATION OF THE EYE.

The rays of light which come from objects which approach the eye within a certain distance are no longer parallel, and therefore are no longer brought to a focus in the retina by the dioptric system at rest. An alteration (an increase) of curvature of one, or of several, of the light-refracting surfaces of that system, or a change in position of the retina, becomes necessary to cause diverging rays, after passing through the dioptric system, to come to a focus in the retina. Now the cornea and retina of the normal (emmetropic) eye, as observation has shown, do not alter their curvature. The elastic, highly compressible, crystalline lens alone is capable of doing so.

The act of adapting or "adjusting" the focal distance of the dioptric system of the eye, so that a defined image of objects should be formed in the retina, is termed the act of accommodation, or the accommodation ($=$ A) of the eye. The power, which is required to produce this change, is termed the power of accommodation, or the adjusting power of the eye ($= \frac{1}{A}$).

The power of accommodation has reached its limit if it no longer brings diverging rays to a focus in the retina.

THE MECHANISM OF ACCOMMODATION.

Let us suppose both eyes to be directed to an object placed at a distance of from 20 to 30 feet, or farther, and this object to be seen distinctly. At that distance the eyes, to see the object distinctly, are supposed to be directed straight out, i. e. their visual lines to be directed to the object, and to be parallel with each other, or nearly so. The accommodation is supposed to be at rest, i. e. the ciliary muscle to be completely relaxed, and the curvature of the crystalline lens of each eye at its minimum. The rays of light which come from objects placed at great distances are parallel, or nearly so, and are brought to a focus in the retina, and the object is seen distinctly by virtue of the refraction or refractive power of the eye alone, the retina being placed at the principal focal distance of the dioptric system.

Proofs of the complete relaxation of the accommodation (of the ciliary muscle) when looking at distance, the visual lines being parallel, are,

(1.) The peculiar sensation of relief of muscular tension experienced when directing the eyes from a near to a distant object, and the sensation of repose when looking at distant objects.

(2.) The possibility of paralysing the accommodation by atropia, under which circumstance only objects at a certain distance can be seen distinctly.

(3.) The occurrence of paralysis of the accommodation through disease, distinct vision for distant objects remaining unaltered.

Efforts at accommodation become necessary whenever objects, which we wish to see distinctly, are so placed that the refraction alone no more suffices to bring the rays coming from them to a focus in the retina. This is the case when the rays of light coming from objects are no longer parallel, nor nearly so, but become more diverging. The nearer an object approaches the more do the rays, coming from it, diverge, and the position of the retina remaining unaltered, the farther behind the retina do they come to a focus, unless some change occurs in the refraction.

The retina may originally lie too near (hypermetropia) or too far (myopia) from the dioptric system; but like the cornea it cannot alter its curvature at will.

That the curvature of the cornea remains unaltered during the act of accommodation is shown by the reflex image (e. g. the flame of a candle) on the surface of the cornea not altering in size or shape, whether the eye views near, or distant objects. When comparing the reflex image formed e. g. on the surface of a spherical convex glass lens of 2″ focus with the one formed on a lens of 10″ focus, we find the image formed on the sur-

face of the latter lens much larger than that which is seen on the former. An alteration in the size of the reflex image indicates a change in the curvature of the surface to which the image belongs.

By means of optical instruments it has been proved that the anterior surface of the crystalline lens chiefly, and the posterior surface very slightly, show changes in the reflex image, when the eye is directed to objects placed at different distances. This change necessarily indicates a change of curvature of these surfaces. Now the more the rays of light diverge from a point, the more convex must a refracting surface be, in order to bring these rays to a focus upon a surface the distance of which, from the lens, remains unaltered; and the smaller does the reflex image appear, which is seen upon the refracting surface. Such, as observation shows, is the case especially with the anterior surface of the crystalline lens.

The crystalline lens, by virtue of its physical properties, is particularly adapted to undergo changes in shape and curvature. Its degree of curvature is lowest if the mechanism of accommodation is at rest, i. e. when the eye is not exerting its accommodation. Every effort at accommodation alters the curvature of the lens. It is supposed that the ciliary muscle, by acting upon the ciliary processes, and through these upon the fluid which intervenes between them and the margin of the crystalline lens, increases the curvature of the surfaces of the lens. These surfaces become less convex through the tendency which the crystalline lens has to assume the least possible curvature, i. e. "to return to a state of rest," as soon as the action of the ciliary muscle becomes less or ceases.

The arrangement of the blood-vessels of the ciliary region renders it probable that, during contraction of the ciliary muscle, the influx of blood into the ciliary processes is impeded, and that they contain less blood. The efflux of venous blood from the processes is supposed not to be impeded, since these veins do not pass through the muscle.

This supposition is supported by the observation made on albinos, that during accommodation the ciliary processes become shorter; during paralysis of the ciliary muscle, larger. The contraction of the ciliary muscle, besides impeding the influx of arterial blood into the ciliary processes, assists in widening the veins of the "circular sinus."

When adjusting the eye for near objects, the following changes occur :—

(1.) The crystalline lens becomes thicker in its middle, and its anterior surface more convex. The convexity of the posterior surface also becomes slightly increased.

(2.) The pupil becomes contracted, and its margin, remaining in contact with the surface of the lens, approaches the cornea, while the iris recedes near its insertion. Thus the anterior chamber gains in depth near the

insertion of the iris what it loses opposite the pupil. The distance of the anterior pole of the lens from the nearest point of the surface of the cornea amounts to ·14173 in. when the accommodation is at rest, and to ·12598 in. when the eye (aged 20) is accommodated for its nearest point of distinct vision.

The following are proofs that the crystalline lens and the parts which alter the curvature of its surfaces are the sole parts of the eye which are used in accommodation.

(1.) All the external muscles of the eye may be paralysed, or the iris may be missing, without the accommodation being disturbed.

(2.) The results of observation with the phacoidoscope (an instrument used to observe the reflex image, e. g. of a flame, formed on the surfaces of the crystalline lens) and with the ophthalmometer (an instrument with which the size of the image can be measured). Observation has shown, as regards the anterior surface of the crystalline lens, that the more strongly the eye is accommodated the smaller does the reflex image appear, and the more does it approach the one formed on the anterior surface of the cornea.

(3.) The changes of curvature of the crystalline lens suffice to explain the range of accommodation, which range is entirely missing when the crystalline lens is missing.

THE RANGE OF ACCOMMODATION.

We distinguish :—

(1.) The absolute range of accommodation ($= \frac{1}{A}$) i. e. the range of accommodation of each eye separately.

(2.) The binocular range of accommodation ($= \frac{1}{A2}$) i. e. the range of accommodation when both eyes are used together.

(3.) The relative range of accommodation ($= \frac{1}{A1}$) i. e. the range of accommodation which we have at our command while the convergence of the eyes (visual lines) remains unaltered. Healthy (= emmetropic) eyes, when distinctly seeing an object placed at 10″, 20″, &c., from both eyes, are accommodated for the distance of 10″ or 20″, &c. Both eyes at the same time are directed or converge towards the object situated at that distance. Thus far a convergence towards an object placed at 10″ or 20″ corresponds to an accommodation for the object placed at those distances.

By experiment, it has, however, been found :—

(1.) That to a limited extent the convergence can be altered without altering the state of accommodation, so that, e. g. the eyes can be directed to a point situated at 8″ or at 12″ from both eyes, while they remain accommodated for a point situated at 10″.

(2.) That to a limited extent the accommodation can be altered without changing the convergence of the eyes, so that, e. g. both eyes being

directed to a point situated 10″ from both eyes, these with the same convergence can also see distinctly a point situated at 50″ from both eyes. The first fact is proved by looking through weak prisms at an object placed at 10″, when the convergence of the eyes changes to avoid diplopia, while the acuteness of vision remains unaltered. The second fact is shown by the power we possess to see distinctly an object placed, e. g. at 10″, while looking through convex or concave lenses of varying strength, which necessarily alter the accommodation, without altering the convergence of the eyes.

The relative range of accommodation varies according to the degree of convergence. In healthy eyes that range is greatest when both eyes are directed to a point which is about 12″ distant from the eyes. Both eyes, while converging towards that point, can, without altering their convergence, distinctly see a point situated at 72″ from both eyes, or one situated at about 5″ from both eyes.

That part of the range of accommodation, which enables both eyes to see distinctly an object which lies nearer than the point towards which both eyes converge, is termed the positive part of the relative range of accommodation. The range of accommodation, which is necessary to see distinctly an object which lies farther from the eyes than the point towards which they converge, is termed the negative part of the relative range of accommodation.

To be able to read, or to do near work, for a prolonged period, it is necessary that the accommodation should be maintained for the distance at which the work has to be done. It has been found by experiment, that, to do this, the positive part of the relative range of accommodation should bear a certain relation to the negative part. This relation varies in differently-shaped eyes.

The power or range of accommodation decreases gradually *as age advances.* This decrease may be due to decrease in the strength of the ciliary muscle. It is, however, readily explained by alterations in the consistence of the crystalline lens. The lens becomes firmer, and the amount of contraction of the ciliary muscle, which at the age of 10 could produce a certain increase of convexity of the lens, can no longer do the same at the age of 20 or 30, &c. The effect of increased firmness of the crystalline lens on vision is that objects, which at the age of 10 could be seen distinctly at 3″ or 4″ from both eyes, at the age, e. g. of 30, to be seen distinctly have to be held at 6″ or still farther from the eyes.

The effect of age on the accommodation therefore is, that the nearest point of distinct vision recedes from the eyes.

About the age of 40 that point generally lies at 8 in. from the eyes. (See Presbyopia).

Mode of ascertaining the power or range of accommodation, and the amount of power of accommodation used when adjusting the eye for objects situated at different distances.

The farthest point of distinct vision of an eye, as stated under refraction, is expressed by the letter r (= punctum remotissimum) e. g. r = 12 in. signifies that the farthest point of distinct vision lies at 12 in. from the eye; r = ∞ signifies that the farthest point of distinct vision lies at "infinite" distance from the eye, i. e. at a distance at which the rays, coming from an object situated at r, are parallel or nearly so before entering the eye.

The distance of r from the eye is expressed by the capital letter R. For the method of ascertaining the farthest point of distinct vision, see Refraction.

The nearest point of distinct vision of any eye is expressed by the letter p (= punctum proximum) and the distance of the point p from the eye by the letter P.

The range or power of accommodation is expressed by the formula $\frac{1}{A}$.

To ascertain the range of accommodation or $\frac{1}{A}$ of an eye, we must determine the distances R and P, i. e. the distance of the farthest (r) and that of the nearest (p) point of distinct vision from the eye.

By this we have ascertained the extent to which the curvature of the crystalline lens has been increased, when adjusting the eye for the nearest point of distinct vision. We have thus determined the power or range of accommodation of the eye.

The nearest point of distinct vision (p) may be ascertained with types, e. g. with test type, No. 1. This type is brought nearer and nearer the eye under examination, until the outlines of the letters become diffused. The point preceding the one at which the letters appear indistinct is the nearest point of distinct vision, and its distance from the eye is expressed in inches, and measured by placing one end of a tape measure level with the test type, the other end level with the margin of the cornea.

Suppose we have found the farthest point of distinct vision to be situated at infinite or at great distance from the eye under examination, we express this by $R = \infty$ or $\frac{1}{R} = \frac{1}{\infty}$. If we have found the nearest point of distinct vision to be situated at 4 in. from the eye, we write P = 4 in. or $\frac{1}{P} = \frac{1}{4}$. We thus express that this eye, when using all its power of accommodation, is accommodated for a point situated at 4 in., and that the rays coming from that point, after refraction by the dioptric system, are brought to a focus in the retina, as are those which come from objects situated at a great distance.

Let us suppose the cornea and crystalline lens represented by a biconvex spherical glass lens of 5 in. focal distance ($= \frac{1}{5}$) and a screen representing the retina placed at the principal focal distance of the lens

i. e. at 5 in. from it. Parallel rays, or rays which are but slightly divergent, i. e. those which come from very distant objects, passing through the lens, are brought to a focus on the screen. This fact is expressed by the sign $\frac{1}{\infty}$. This sign, applied to the refraction of the eye, always indicates that the rays of light, refracted by the cornea and crystalline lens, were, previous to their refraction, parallel or only slightly divergent, and that they are brought to a focus in the retina without any effort of accommodation, i. e. without any increase in curvature of the light-refracting parts being required.

Now the nearer an object is brought to the convex lens the farther behind the screen is its image formed, i. e. the more do the rays, coming from it, diverge, and the farther behind the screen are they brought to a focus, unless we substitute a convex lens of greater refracting power (a "stronger convex lens"). (This increase of the refracting power the eye effects by the power of accommodation.)

Suppose the flame of a candle to be placed at 20 ft. or at (12×20) 240 in. from the convex lens; the rays coming from the flame are supposed to be parallel, or nearly so, and are brought to a focus upon the screen at the principal focal distance of the convex lens. If the flame is brought to 200 in., and if a distinct image of it is no longer formed on the screen, it is because the rays coming from the flame are no longer parallel, but diverging, and come to a focus behind the screen.

The refracting power of the lens has to be increased by $\frac{1}{200}$, and instead of the spherical convex lens of $\frac{1}{5}$, we require one of $\frac{1}{5} + \frac{1}{200}$, if we wish again to bring the rays to a focus upon the screen, i. e. to make them pursue the same course after refraction which parallel rays had.

If the flame is brought to 100″ from the lens of $\frac{1}{5}$, then its refracting power has to be increased to $\frac{1}{5} + \frac{1}{100}$; if the flame is brought to 10″, we require instead of the convex lens of $\frac{1}{5}$, one of $\frac{1}{5} + \frac{1}{10} = \frac{3}{10} = \frac{1}{3\frac{1}{10}}$ to bring the rays coming from the flame to a focus in the retina, &c.

The refracting power of convex or concave spherical lenses is inversely proportionate to their focal distances. A spherical convex lens of 5, 10, 20, &c., inches focal distance may therefore also be described as a spherical convex lens of a refracting power of $\frac{1}{5}$, $\frac{1}{10}$, $\frac{1}{20}$, &c.

To express the range or power of accommodation a similar mode is adopted, e. g. if a normal (emmetropic) eye is accommodated for a distance of 5, 10, 20, &c., inches, its adjusting power required for these distances is expressed by $\frac{1}{5}$, $\frac{1}{10}$, $\frac{1}{20}$, &c. An eye accommodated for parallel rays is using no adjusting power: this is expressed by the sign $\frac{1}{\infty}$. To express the amount of power required for adjusting or accommodating the eye from a farther to a nearer point, we must deduct the adjusting power used for the farther point from that used for the nearer point of distinct

vision. For instance we wish to state the amount of power which is required to adjust an eye for a point situated at 5 in. from the eye (thus using adjusting power equal to $\frac{1}{5}$), which eye previously had been adjusted for a point situated at 20 in. (then using adjusting power equal to $\frac{1}{20}$). The amount of power which has been used to adjust the eye from a point situated at 20 in., to one situated at 5 in., from the eye, or, in other words, to adjust the eye from $\frac{1}{20}$ to $\frac{1}{5}$, may be expressed by deducting $\frac{1}{20}$ from $\frac{1}{5}$. $\frac{1}{5} - \frac{1}{20} = \frac{3}{20} = \frac{1}{6\frac{2}{3}}$ $(\frac{1}{A} = \frac{1}{6\frac{2}{3}})$.

If the eye is adjusted for parallel rays, the adjusting power is $= \frac{1}{\infty}$, i. e. at rest $(= \frac{1}{A} = \frac{1}{\infty})$. If, then, it becomes adjusted for an object placed at 10 in., adjusting power equal to $\frac{1}{10}$ is required. To express the amount of adjusting power which is required to adjust the eye from $\frac{1}{\infty}$ to $\frac{1}{10}$, we have to deduct $\frac{1}{\infty}$ from $\frac{1}{10}$. $\frac{1}{10} - \frac{1}{\infty} = \frac{1}{10}$ $(\frac{1}{A} = \frac{1}{10})$. If the nearest point of distinct vision lies at 5 in., in other words, if the eye cannot adjust itself for an object which is placed nearer than 5 in., then the total adjusting power $= \frac{1}{5}$. The amount of power of accommodation required to adjust the eye from an object placed at 10 in. to one placed at 5 in. is equal $\frac{1}{5} - \frac{1}{10} = \frac{1}{10}$. It thus follows, that the eye uses as much adjusting power to adjust itself from $\frac{1}{\infty}$ to $\frac{1}{10}$ (i. e. when looking from a very distant object to an object placed at 10 in. from the eye), as it does when adjusting itself from $\frac{1}{10}$ to $\frac{1}{5}$ (i. e. when looking from an object placed at 10 in. to one placed at 5 in. from the eye).

The region of accommodation.

The distance from the farthest to the nearest point of distinct vision is termed the region of accommodation. A person whose farthest point of distinct vision lies at 30″, and whose nearest point of distinct vision lies at $7\frac{1}{2}$″, has a region of accommodation of $22\frac{1}{2}$″; one who can see distinctly from 10″ to 5″ has a region of accommodation of 5″; one who can see from infinite distance (∞) to 10″, has a region of accommodation extending from ∞ to 10″.

To see distinctly from ∞ to 10″ a range or power of accommodation of $\frac{1}{10}$ is required (since $\frac{1}{\infty} - \frac{1}{10} = \frac{1}{10}$); to see distinctly from 10″ to 5″, a range of accommodation of $\frac{1}{10}$ is required, since $(\frac{1}{5} - \frac{1}{10} = \frac{1}{10})$ and to see distinctly from 30″ to $7\frac{1}{2}$″ a range of accommodation of $\frac{1}{10}$ is required (since $\frac{1}{30} - \frac{1}{7\frac{1}{2}} = \frac{1}{10}$).

In the three instances the region of accommodation varies much, and yet the same power of accommodation is required to see distinctly at the distances mentioned. In all three the curvature of the crystalline lens must be increased to an extent which is equal to a convex lens of $\frac{1}{10}$ or

one of 10″ focus, to enable the eye to obtain the stated region of accommodation.

EXAMINATION WITH THE OPTHALMOSCOPE. (= OS.)

The instruments necessary for the examination are—an ophthalmoscope and a spherical lens.

The ophthalmoscope consists (*a*) of a slightly concave circular mirror of a focal length of from twelve to fifteen inches. The mirror should have a diameter of about two inches, and be mounted in a light frame of tortoise-shell, horn, or gutta-percha, with a broad rim to admit of its being held securely. (*b*) A circular portion (diameter about one-sixth of an inch) of silvering is removed from the centre of the mirror. Thus a sight-hole is obtained. (*c*) To this corresponds an opening of equal size in the frame.

The spherical convex lens should have a focal distance of from two to three inches. It should be mounted in the same material as the ophthalmoscope, with a broad rim, so that, when laid flat upon a table, it rests upon the rim, and does not become scratched.

Position of Observer and of Patient.

(*d*) Both are seated in a dark room facing each other. The eyes of the observer should be level with, or an inch or two above, those of the patient. (*e*) A gas-light is placed at the side and somewhat behind the

(*a*) Among the great variety of ophthalmoscopes must be mentioned—the Binocular Ophthalmoscope, the Auto-Ophthalmoscope for examination of one's own eyes, the Ophthalmoscope with micrometer, &c., fixed on a stand, and the Ophthalmoscope for viewing the image reflected from the interior of the eye in a second reflecting surface.

Any good light-reflecting surface may be used as an ophthalmoscope, as long as the observer is placed in a position to receive the light returning through the pupil of the examined eye into his own. The ophthalmoscope described above answers all practical purposes.

(*b*) More light is gained by not having a hole bored through the glass to establish the sight-hole; and the direct ophthalmoscopic examination is much facilitated.

(*c*) Attached to the back of the frame of the ophthalmoscope used at the Hospital is a contrivance which may be used as a handle, thus facilitating manipulations with the ophthalmoscope; but which is principally intended for receiving any spherical or other lens we may wish to place there for more minute ophthalmoscopic examination.

(*d*) Both may stand, or one, or both be seated, or the patient lie down, or the observer stand behind the patient, and view the image of the optic disc, &c., received upon a piece of glass, mirror, &c., which is held in front of the patient's eye, and receives the rays of light which return from the interior of the eye.

(*e*) The gas-light, by placing round it a pale blue glass, becomes whiter and less trouble-

patient's head and level with his eyes, so that no light, but that which is reflected by the ophthalmoscope, falls upon the eyes.

Mode of examination of the different parts of the Eye.

Every ophthalmoscopic examination should be preceded by the examination with lateral illumination. All alterations in the appearance of the deeper parts of the eye, arising from anomalies in front of the vitreous chamber (in the cornea, lens, &c.), can with the greatest accuracy be recognized if the ophthalmoscopic examination is preceded by that with lateral illumination. This is followed by examination of the vitreous chamber. (See Vitreous Substance.)

For the direct ophthalmoscopic examination (or for the examination of the erect image) we require the ophthalmoscope only. By this method we obtain a correct view of the colour and relative position, and also a much enlarged view of the parts examined.

For the indirect ophthalmoscopic examination (or "the examination of the inverted or aërial image") we make use of the ophthalmoscope and of the spherical convex lens. We can overlook more parts at one glance, but we see them inverted, e. g. what appears as the upper margin of the optic disc is in reality the lower one, &c.

Examination of "the inverted image," or indirect ophthalmoscopic examination.

Suppose we wish to examine a healthy right eye with blue iris, the pupil being dilated by atropia (*f*), and the observer patient, and the gas-light being placed as directed above; we take the ophthalmoscope in the right hand, grasping its margin with the thumb and fore-finger, and turn the reflecting surface towards the patient. We "throw" the light upon the right eye, and approach the eye with the ophthalmoscope until the circular surface of light on the patient's face has nearly the size of that of the ophthalmoscope. We must take care continually to keep the circular surface of light on the patient's eye while raising the ophthalmoscope to our own right eye. When looking through the sight-hole, we perceive the patient's pupil to appear brilliant red instead of black.

some to the observer. Any light, the flame of a candle, &c., may be used. Amaurotic persons are best examined by sun-light.

The ophthalmoscopic examination may be carried on in a light room as long as sufficient light is thrown through the pupil of the eye under examination to distinguish the details of its optic disc, &c.

(*f*) A solution of a quarter of a grain of sulphate of atropia to half an ounce of distilled water is used. The optic disc and the tunics, where immediately adjoining it, can, with very few exceptions, be examined without the use of atropia.

If it appears black, we either do not throw the light upon the pupil, or we do not look through the sight-hole of the ophthalmoscope.

Supposing we have obtained the red reflection from the pupil, we at once look for the optic disc, which is most quickly found (the ophthalmoscope being held by the thumb and fore-finger) by holding up the little finger of the same hand, and directing the patient to look at the tip of it. The centre of the yellow spot of the patient's right eye is thus directed to the tip of that finger, and the optic disc comes to stand opposite the pupil. A change in the colour of the reflection from the pupil, from red to whitish-red or brilliant white, indicates that the optic disc is in view. The observer should persist in his endeavours until he has obtained the brilliant whitish reflection. In persons with dark irides the difference in the reflection from the pupil is still more striking, on account of the contrast of colour between the optic disc and the tunics.

Having obtained the reflection peculiar to the optic disc, we place the convex lens (holding it between the fore-finger and thumb of the left hand) before the eye under examination. The diffused image of the flame, which is "thrown into the eye" by the ophthalmoscope, serves to illuminate those parts of the interior of the eye which lie within the area of the flame. The rays of light reflected, e. g. from the optic disc thus illuminated, have to pass through the lens held in front of the patient's eye, and an inverted defined image of the optic disc, &c., is formed in front of this lens, i. e. between it and the observer.

In this case we do not directly examine the optic disc, but only its inverted aërial image; hence the term examination of the inverted image by the indirect method, or indirect ophthalmoscopic examination.

The little finger of the hand which holds the lens is placed on the patient's cheek, to steady the lens, while the middle or ring finger is kept disengaged, to be placed, if necessary, upon the margin of the upper lid, so as to raise it, or gently to press upon the eyeball, to produce and watch the pulsation of the retinal artery in the optic disc.

The spherical convex lens is held at from one to two inches from, and somewhat obliquely in front of, the patient's eye.

If the lens is held vertically the image of the ophthalmoscope, which appears upon each surface of the lens at its centre, interferes with the view of the part beyond. If the lens is held obliquely, the two images recede from each other. By approaching the lens to, or removing it from, the eye under examination, we soon succeed in obtaining a distinct view of the well-defined (aërial) image of the optic disc, &c.

This image can be enlarged by our placing behind the sight-hole of the ophthalmoscope a convex lens of greater focal distance (one of from ten to twenty inches focal distance).

After having seen the optic disc, we proceed to the examination of the

region of the yellow spot (see Retina, examination of the), and then to that of the more peripheral parts of the tunics, by directing the patient to turn the eye in different directions while the ophthalmoscope and convex lens remain unaltered in position.

Examination of "the erect image," or by the direct method, or direct ophthalmoscopic examination.

The gas-light is placed more at the side, and level with the left eye, supposing again that we examine the right eye. We direct the patient to "look straight out," and sitting, or better standing, in front, we look for the place occupied by the optic disc.

The optic disc occupies a portion of the interior of the eye situated internal to, and a little below, the yellow spot.

As soon as we perceive the reflection peculiar to the optic disc (and not before) we should slowly approach the eye from a distance of from 12 to 15 inches, taking care continually to throw the light through the pupil, and not to lose sight of the reflection peculiar to the optic disc. On approaching very near the eye, only a small (the central) portion of the ophthalmoscope remains available, and some practice is required so as continually to illuminate the interior of the eye. As long, however, as we do not lose sight of the reflection peculiar to the disc we may be sure that we are handling the ophthalmoscope properly.

From the degree of distinctness with which we see the optic disc, and the blood-vessels in it, while approaching the eye, we can form a general idea of the refraction (of the shape) of the eye. If the optic disc appears *the more distinct the nearer we approach the eye,* we pronounce the eye to be too short (hypermetropic); if the optic disc appears *the more indistinct the nearer we go,* we infer the eye to be too long (myopic); if we only see the optic disc distinctly after having approached the eye to within about three-quarters of an inch, we consider the eye to be normal in shape (emmetropic), or but very slightly myopic, or hypermetropic.

This method of ascertaining the refraction, though not equal, as regards accuracy, to the one obtained by examination with spherical, &c., lenses, is the quickest means of furnishing the key to the state of refraction in moderate and in higher degrees of ametropia, and should be well practised.

The observer's eye, for this and the indirect ophthalmoscopic examination, if not emmetropic, should be made so, by placing that spherical lens which corrects the faulty refraction behind the sight-hole of the ophthalmoscope.

The optic discs of emmetropic and of hypermetropic eyes can readily be

examined directly. The optic disc of the myopic eye requires the concave lens, which corrects the myopia, to be placed behind the sight-hole of the ophthalmoscope.

On approaching with the ophthalmoscope to within about an inch from the patient's eye we distinctly see the entire optic disc or part of it, its vessels, and part of the adjoining tunics. The patient's cornea and crystalline lens act, in this case, as a strong magnifying lens. The optic disc often appears so much enlarged that, though the pupil be dilated to its utmost, we cannot overlook the entire disc at once, but to do so have to look into the eye from different directions.

The direct mode of examination, besides assisting us in determining the shape and the refraction of the eye, admits of our seeing the details of the optic disc, and of the tunics near it, better, more quickly, and more easily than any other method.

Having seen the optic disc, we inspect the tunics, by looking in different directions through the pupil.

SPECTACLES.

Glasses inserted into a spectacle frame are termed *lenses*, if they refract the light. Some spectacle glasses are made of transparent *plane glass*, simply to protect the eyeball; others are *tinted* to moderate the light; discs of metal, or some other opaque substance, with a round or slit-shaped opening, may occupy the place of lenses in the spectacle frame. These latter are termed *stenopæic spectacles.*

The spectacle lenses which are generally used are *spherical or cylindrical, or a combination of both.*

Both surfaces of *a spherical lens* are equally convex or concave ("are ground with equal radii of curvature"), and form parts of a sphere. The greater the curvature ("the shorter the radius of curvature") the "stronger" is the lens, i. e. the greater is its refractive power, and the shorter its focal distance. The centre of such a spherical lens (termed the optical centre) lies midway between the points of greatest curvature. A line passing through these points and the centre is termed the axis of the lens. The rays of light which coincide with the axis are the only ones which are not refracted by the lens.

The spherical bi-convex or converging lens unites the rays which impinge upon one of its surfaces, into a real focus, or focal point, which lies at some distance from the other surface. The point of union of parallel rays is termed *the principal focus* of the lens. The point of union of rays which diverge from a point is termed *the conjugate focus.*

The distance of the point of union of rays (their focus) from the lens is termed *the focal distance.*

In spectacle lenses this distance is measured from the centre of the lens to the focal point, and is expressed in inches. In the box supplied by Smith and Beck the focal distance (in English inches) is inscribed on each lens. In writing, the focal distance of a lens may be expressed either by a fraction which states the refracting power of the lens (the refracting power is inversely proportionate to the focal distance of the lens), or simply by stating the focal distance.

Thus spectacles of $\frac{1}{40}$, $\frac{1}{20}$, $\frac{1}{10}$, or of 40-inch, 20-inch, 10-inch convex, or of $+40$ $+20$, &c., are those which contain lenses, each of which has a positive focal distance of 40, 20, or 10 English inches.

Spectacles of $-\frac{1}{40}$, $-\frac{1}{20}$, or $-\frac{1}{10}$, or spectacles of 40-inch, 20-inch or 10-inch concave, or of —40, —20, &c., are those which carry lenses, each of which has a negative focal distance of 40, 20, or 10 English inches.

A spherical bi-concave or diverging lens does not unite the rays into a focus, but after refraction causes them to assume a direction as if they had proceeded from a point situated on that side of the lens from whence the rays have come. This point is termed its focus or virtual focus.

A lens is the stronger the greater its refracting power, or the shorter its focal distance. A lens of $\frac{1}{5}$ or of 5-inch focal distance is a stronger convex lens than one of $\frac{1}{10}$ or of 10-inch focal distance, and one of $\frac{1}{10}$ stronger than one of $\frac{1}{20}$. A lens of $-\frac{1}{5}$ is a stronger concave lens than one of $-\frac{1}{10}$, &c.

We may, with tolerable accuracy, ascertain the focal distance of the lenses of a pair of spectacles by placing, in succession, lenses of opposite curvature upon the one, the focus of which we wish to ascertain, until we have found the lens which no longer alters the size of an object (e. g. of two parallel lines) when viewed through both the lenses.

Suppose a concave lens of 10-inch (a-$\frac{1}{10}$) placed upon a convex lens, the focus of which we wish to ascertain, causes parallel lines to appear as they do without the lenses, this being held at 10 in. from the lines, we infer that the convex lens has a focal distance of 10 inches (is one of $\frac{1}{10}$).

Occasionally spherical lenses are used, which have a double focus e. g. the curvature of the upper half, or of the upper third of the lens, may be less convex (having e.g. a focal distance of 36 in. or of 40 in. or being plane), while the lower half is more convex (with a focal distance of from 10 in. to 20 in.).

Sometimes half or two-thirds of the surface of a lens is blackened so as to ward off light, or to cause the eye to see in certain directions only.

At the Hospital a box is used with a number of lenses termed trial-lenses. The box of trial-lenses sold by Smith and Beck, Opticians,

Cornhill, London, contains 36 pairs of convex and 36 pairs of concave spherical lenses, their focal distances (positive or negative) ranging between 1 inch (1″) and 100 inches (100″). The box also contains blank discs (for exclusion of one eye), discs with small apertures for stenopæic purposes, and a spectacle frame which admits of vertical and of horizontal displacement of the parts which carry the lenses.

Cylindrical lenses.—Of these the simple cylindrical, the spherico-cylindrical, and the bi-cylindrical lens are in use. The latter is rarely employed.

A simple cylindrical lens is either positive (having a convex curvature with a positive focal distance) or negative (having a concave curvature with a negative focal distance). The focal distance of course refers to that surface of the lens which is curved.

The letter "c" placed after the sign which indicates the focal distance of a lens, signifies cylindrical; the letter "s" signifies spherical e.g. $-\frac{1}{10}$ s, $-\frac{1}{20}$ c signifies the former a spherical concave lens of 10-inch focus, the latter a cylindrical concave lens of 20-inch focus: $\frac{1}{20}$ c signifies a simple positive cylindrical lens; $-\frac{1}{20}$ c signifies a simple negative cylindrical lens of 20-inch focus.

Rays which pass in a plane, which we suppose carried through the axis of the cylindrical curvature, are not refracted by a cylindrical lens. Rays which pass in a plane, carried perpendicularly to the axis of the cylindrical curvature, are refracted, and come to a focus at the focal distance of the curvature.

One or both surfaces of a cylindrical lens may be cylindrical. Their axes of curvature are parallel, if both are cylindrical.

In Smith and Beck's box of trial-lenses there are 18 positive and 18 negative cylindrical lenses, the focal distances ranging between $2\frac{1}{2}$ and 50 English inches.

The spherico-cylindrical lens is a combination of a surface of spherical, with one of cylindrical curvature. Suppose the focal distances of the two surfaces to be positive, the spherical surface to have a focal distance of 10 in., and the cylindrical surface one of 20 in., we write $\frac{1}{10}$ s $+$ $\frac{1}{20}$ c. If the focal distance of both surfaces is negative we write $-\frac{1}{10}$ s $+ -\frac{1}{20}$ c. The focal distance of the spherical surface of each of these lenses in a section through the axis of the cylindrical surface is 10 in.; in a section perpendicular to that axis it is $(\frac{1}{10}+\frac{1}{20}=\frac{3}{20})$, or a little more than 6 in.

The bi-cylindrical lens. Both its surfaces have a cylindrical curvature, one of which is generally convex, the other concave, their axes standing perpendicular to each other. $\frac{1}{10}$ c $\lceil$ $-\frac{1}{20}$ c signifies a bi-cylindrical lens, the curvature of one of its surfaces having a positive focal distance of 10 in., the other of its surfaces having a negative focal distance of 20 in.

Spectacles with cylindrical lenses should be placed as near the eyes as possible; the surfaces with least curvature should stand next the cornea.

Each lens, before being finally fixed in the spectacle frame, is set in a ring, which admits of rotation of the lens before the eye. The patient can thus ascertain the direction of the axis of the lens, by which vision is most improved.

The lenses of spectacles generally have an oval shape. Large round lenses are better, since they cover the pupil more completely during movements of the eye. Lenses made of crown glass are cheaper, and disperse light less.

The spectacle frame is generally made of steel. The side pieces of the frame should be sufficiently long to grasp round the widest part of the head. The bridge of the frame should adapt itself properly to the bridge of the nose. If concave lenses are to be used, great care should be taken that the frame fits well. The heavier the lenses are the stronger must be the frame.

The spectacle frame of the box of trial-lenses has elastic rings, to allow the insertion of any one of the lenses. The rings are moveable on a graduated cross bar, by which the distance of the lenses from each other and from the bridge of the nose can be accurately ascertained.

The following points should be attended to, as regards the distance of the lenses from each other :—(1.) Ascertain the distance for which the spectacles are to be used; and while the patient looks at an object placed at that distance, make a mark on the margin of the lower lid of each eye, below the centre of the pupil. The distance between these two points is measured, and the optician is directed to place the lenses so that their centres are at that distance from each other.

Both eyes diverge if the concave lenses of a pair of spectacles stand too near, or the convex lenses too far apart. The lenses in both cases act as prisms.

(2.) The spectacles should be worn as near the eyes as possible. The distance of each lens from the corresponding cornea should never exceed a quarter of an inch. The stronger the lenses are, and the further they stand from the cornea, the more do convex lenses enlarge, and concave ones diminish, the size of the images in the retina.

When prescribing spectacles we state on the card which the patient takes to the optician—(1.) The focal distance of the lens for each eye. (2.) Whether the spectacles are to be used for "reading" or for "distance." In unusual cases we also state the distance of the axis of one lens from that of the other.

Stenopæic ($\sigma\tau\epsilon\nu o\varsigma$, *narrow, and* $o\pi\eta$, *window*) *Spectacles.*

In these spectacles the place of lenses is occupied by shells of horn or of thin brown leather blackened inside. Each shell is pierced in the centre, or the centre is occupied by a thin perforated metal plate. The perforated part has to stand as near to the cornea as possible. The opening should have a conical shape, and the apex of the cone should be nearest the cornea.

The opening must be the smaller the larger the corneal opacity. Its diameter generally varies between $\frac{1}{3}'''$ and $1'''$.

Different-sized apertures may have to be made in the same plate, so as to enable the patient to change them according to the different degrees of light. The margin of the shell should adapt itself to the margin of the orbit, and exclude side-light as much as possible.

Prisms.

In the box of trial-lenses is a series of prisms. The angle of refraction (the angle which the refracting surfaces make with each other) varies in different prisms from 3 to 18 degrees (3° to 18°), and is marked on each prism. In each prism we distinguish the base, the two smooth refracting surfaces, and the line where these meet (the angle).

A prism is termed a spherico-prismatic lens, if the surfaces are convex or concave. Such lenses are rarely employed since spherical lenses, when placed more or less near each other in the spectacle frame, can be made to act as prisms.

Prisms are made of crown glass, which disperses the light less than other glass.

Rays of light, passing through the refracting surfaces of the prism, are refracted towards the base of the prism. The prism is termed strong if its refracting angle is great. A prism with a refracting angle of 20 degrees (20°) is stronger than one with a refracting angle of 10°. The prism of 20° causes the distance of the double image from the true one to be ·12440 in. That distance amounts to ·06220 in., with a prism of 10°.

A prism is termed "completely correcting" if it removes the insufficiency of a muscle; and "incompletely correcting" if it only removes the insufficiency as far as the latter interferes with reading.

Prisms with plane surfaces are used—to demonstrate the independence of a certain range of accommodation from a given convergence of the eyes, —to express the degree of diplopia in paralytic affections of the muscles,—to ascertain in some measure the strength of the muscles of the Eyeball—and to assist in the treatment of insufficiency, paresis, &c.

Spectacles with tinted glasses.

These spectacles should only be worn as long as the light "irritates the eyes."

The patient must himself select the tint which is most pleasant to the eyes. For this purpose slips (marked A. B. C., &c.) of plain tinted glass, sufficiently large to permit of both eyes being used at the same time, are given in the box with the trial-lenses.

The carmine red glass, which is found in the box, is used to ascertain the position of the double image in diplopia.

The tinted spectacle glasses should be large and round.

If side-light has to be excluded, this should be done without increasing the weight of the spectacles too much. Convex and especially concave lenses are sometimes required tinted. Blue and neutral tint, or "smoked" lenses, are the only ones that can be recommended.

ANOMALIES OF REFRACTION.

Hypermetropia (*Hyperpresbyopia. Hyperopia* =*H*).

The term Hypermetropia is given to an anomaly of refraction which is connected with a very frequent congenital alteration of the shape of the eyeball. The hypermetropic eyeball not only is too small, but the curvature of its tunics is abnormal, so that the retina comes to stand too close to the crystalline lens. This gives rise to peculiar disturbances of vision.

Alterations in elasticity and in curvature of the light-refracting surfaces with decrease of their refracting power constitute one of the senile changes of the human eye, and give rise to a species of hypermetropia. (See treatment of Presbyopia.)

An eye without crystalline lens, having only the cornea left to refract the light, is also termed hypermetropic, though the position and curvature of the retina be normal.

We shall here treat only of the hypermetropia which is the result of congenital anomaly in shape of the eyeball.

Hypermetropia occurs as a rule in both eyes, and frequently varies in degree in each. It is congenital, and often hereditary.

Extreme hypermetropia is readily recognized by comparing the curvature of the sclerotic, from the outer margin of the cornea towards the nearest part of the optic nerve of the healthy eye, with that of the hypermetropic eye. In the latter the sclerotic round the cornea is too slightly curved. Beyond the greatest transverse diameter of the eye, which appears to lie too near the cornea, it curves too abruptly towards the optic nerve. This acute curvature becomes more conspicuous when the

patient is directed to look towards the nose, so as to expose the outer aspect of the sclerotic. The eyeball appears flattened from before backwards, and its anterior and posterior poles are supposed to stand too near each other.

The palpebral aperture in extreme cases appears much too large for the eyeball, and a recess of conjunctiva is observed near the outer canthus.

For the method how to recognize with the ophthalmoscope the existence, and in a great measure the degree, of hypermetropia, *see* Examination with the Ophthalmoscope; Examination of the erect image, &c. Many of the peculiarities of the hypermetropic eye, observed with the ophthalmoscope, can be explained by the anomaly in shape of the eyeball. Such are—the facility with which we obtain a distinct view of the erect image of the optic disc, and of the retinal vessels at a great distance from the eye,—and the apparent prominence, into the vitreous chamber, of the retina next the optic disc with a corresponding alteration in the course of its blood-vessels.

Peculiarities which are attributed to abnormal development are:—

(1.) A crescentic well-defined white figure skirting the lower margin of the optic disc of one eye, or of both. This figure is readily distinguished from the one observed in myopia by the absence of choroidal atrophy near it; frequently it appears to project into the vitreous chamber.

(2.) A defective blood supply to the retina and optic disc, giving rise to some anæmia of the former. The high degrees of amblyopia occasionally met with in hypermetropia are accompanied by great hyperæmia in some, by anæmia of the optic disc in other cases.

(3.) An oval shape of the optic disc (the long axis of the oval standing vertically).

(4.) An abnormal shape of the eyeball.

The tunics within the sclerotic participate in the alteration in curvature of the sclerotic. The retina, and especially its centre (yellow spot), instead of being placed, as in health, at the principal focal distance of the dioptric system (cornea and lens), lies too near that system. This statement is borne out by dissections, and by measurements on the living eye.

It might be supposed, though the shape of the eyeball be abnormal, that this may be compensated for by increased curvature of the cornea, or of the lens, or of both, or that the retina may occupy its normal position, but that the cornea and lens, or both, may be too flat, and thus prevent the formation of defined images in the retina. Measurements of the corneæ and lenses of hypermetropic eyes have however shown, that their curvatures and positions are normal, or, if deranged, that this rather tends to remedy the faulty positions of the retinæ.

Vision of Hypermetropics. Most of the disturbances of vision of hy-

permetropics must be sought in the too short distance of the retina from the cornea and lens.

The emmetrop sees distant objects without making use of the power of accommodation (the retina being placed at the principal focal distance of the cornea and lens). The hypermetrop cannot do the same. He is obliged, even when looking at distant objects (from which proceed parallel or slightly diverging rays), to use adjusting power, i. e. to cause the ciliary muscle to contract. The hypermetropic eye consumes muscular power, while under the same circumstances the emmetropic eye uses none.

The nearer to the eyes an object is held, the more do the rays diverge which come from the object, and the more adjusting power is required to bring these rays to a focus. Now the hypermetrop, to be able to see distinctly a distant object, is already using adjusting power, as shown above, while the emmetrop is not yet compelled to do so. The hypermetrop, when looking at near objects, therefore, does not start with the same quantity of adjusting power, but has already made use of some, and has not sufficient when much is required ; as, e. g. for prolonged reading.

The disproportion between the shape of the hypermetropic eyeball and the power of accommodation which is necessary to render acute vision possible, has led to the distinction of different kinds and degrees of hypermetropia.

Kinds of Hypermetropia.

(1.) If the shape of the eye is but slightly altered (slight hypermetropia) and the power of accommodation normal, no complaints arise as long as that power suffices for easy distinct vision. The hypermetropia is stated to be altogether *latent* (=*Hl*). Some hypermetropia always remains latent as long as any power of accommodation is left. If the accommodation is paralysed (through atropia) or only slight, as in advanced age, all or most of the hypermetropia becomes manifest.

(2.) If complaints arise as regards vision, they are as a rule an indication that some of the hypermetropia has become *manifest* (= *Hm*). General illness or local causes, which tend to weaken the ciliary muscle, may rapidly cause the hypermetropia to become manifest.

(3.) *Absolute hypermetropia* exists if, with the greatest effort at accommodation, parallel rays or the images of distant objects cannot be brought to a focus in the retina.

The term *relative manifest hypermetropia* signifies a disturbance of the relation between the point towards which the hypermetropic eyes converge, and the point from whence the rays come. For example, if, when reading, the book is held at 16 inches from the eyes, then the rays, which come from the letters, diverge from a point 16 inches distant, while the eyes may converge towards a point situated only at 12 inches from the

eyes. In this case the convergence is too great. With greater convergence more power of accommodation can be exerted, and improvement of vision is obained, which explains the occurrence of this form of manifest hypermetropia. (See Convergent Strabismus.)

Degree.—The degree of hypermetropia necessarily varies with the distance of the retina from the cornea and lens (from the dioptric system), and may be expressed by the refracting power of a convex lens. Such a lens, held close in front of the cornea of the hypermetropic eye, should refract rays which come from very distant objects (termed parallel rays) sufficiently to bring them to a focus in the retina, after entering the eye, (after refraction by the dioptric system at rest, the accommodation being paralysed by atropia).

To determine the degree of the hypermetropia, we must first paralyse the accommodation by atropia, and then find the strongest convex lens which, held close in front of the cornea, brings rays from very distant objects to a focus in the retina. Suppose the hypermetropic eye (its accommodation being paralysed by atropia) to look at a distant object, say at letters No. XL. placed at forty feet, or at letters of No. XX. placed at 20 feet, and we find that, to spell those letters, a convex lens of 20-inch focal distance is required, and that this cannot be done with any stronger convex lens. We in this case state the degree of hypermetropia as $\frac{1}{20}$. If the eye requires a convex lens of 10-inch focal distance, the hypermetropia is $\frac{1}{10}$, &c. The highest degree of hypermetropia on record is one of $\frac{1}{1\frac{1}{2}}$ (requiring a convex lens of $1\frac{1}{2}$-inch focal distance to bring parallel rays to a focus in the retina).

The degree of the manifest hypermetropia, i. e. the degree of the hypermetropia which shows itself when the accommodation is not paralysed, is also ascertained by convex lenses; e. g. if we find that $\frac{1}{20}$ is the strongest convex lens with which letters of No. XX. can be recognized at 20 feet, we state the manifest hypermetropia to be $\frac{1}{20}$ ($Hm = \frac{1}{20}$). If after paralysing the accommodation by atropia, we find $\frac{1}{10}$ to be the strongest convex lens with which letters of No. XX. can be recognized at 20 feet, we state the absolute hypermetropia to be $\frac{1}{10}$ ($H = \frac{1}{10}$). In this case one half of the existing hypermetropia has been masked by the accommodation.

If the power of accommodation is strong, as in young persons, and the degree of the hypermetropia moderate, the latter does not become manifest for a considerable time.

Complaints of the hypermetropic patient.

The hypermetropia, if slight, is not felt, as long as the accommodation can overcome it with ease. The power of accommodation in all eyes

diminishes as age advances, and the higher the degree of hypermetropia the sooner do difficulties of vision (termed asthenopia) arise.

Asthenopia (*Weak sight. Impaired vision. Impaired vision for near work. Dullness of sight. Dimness of vision. Slowly adjusting sight. Affection of the retina from excessive employment. Debilitas visûs. Hebetudo visûs*).

The two groups of muscles which, from want of power, may give rise to asthenopia, are the ciliary muscle and the external muscles of the eyeball.

To be able to read, or to do near work with ease and for a prolonged time, it is necessary that the contraction of these muscles should be possible, and be kept up efficiently for the time of work. Their power of contraction may be destroyed by paralysis, or may become inefficient from paresis or weakness. It may be normal, but become exhausted too soon by the muscles being obliged to do work under circumstances, under which in the normal eye they are at rest, or, at least, are less contracted. The latter is often the case in hypermetropia. The fatigue of the ciliary muscle is accelerated by the tendency which the crystalline lens has to return, by force of its own elasticity, to the shape and curvature which it has when at rest. The continued resistance offered by the crystalline lens tends to distend the contracted fibres of the ciliary muscle, and thus an additional increase of contraction of the muscle becomes necessary.

The term *Accommodative Asthenopia* has been used by some to distinguish the asthenopia which is due to want of power of the ciliary muscle.

Many symptoms, accompanying asthenopia, do not essentially belong to it. We shall first treat of true asthenopia, and then of apparent but not true asthenopia.

True Asthenopia (*Accommodative Asthenopia*).

The patient who suffers from asthenopia complains that, when reading or engaged in other "near work," the letters or the finer details of the work become "dim," or disappear suddenly, or become indistinct gradually. After "rubbing" the eyes, or "closing the lids" for a short time, he is again able to resume the work for some time. In high degrees of asthenopia these attacks of dimness appear frequently; in slighter degrees only during work by artificial light, or after prolonged work. They appear sooner during ill health, or during any other change which affects the contractility of the muscles. Asthenopia may continue for years without ever interfering with acuteness of vision.

In high degrees of hypermetropia the rapidly appearing "dimness" prevents the occurrence of other symptoms of fatigue. In a large number of cases the dimness of vision is preceded by a sensation of tension over the eyebrows, amounting sometimes to pain. The rapidity with which the asthenopia appears and its duration, vary, and are connected with the nature of the work. It has been stated that, in the usual course of hypermetropia, the age, at which asthenopia appears, is about equal to the denominator of the fraction which expresses the degree of hypermetropia, e. g. if the asthenopia appears about the age of ten years the hypermetropia is $\frac{1}{10}$. Asthenopia is more severe and appears sooner in those engaged in much "near work;" though in rare cases it even appears when looking at distant or at near large objects.

The true form of asthenopia is observed in hypermetropia, and in astigmatism.

Persons suffering from true asthenopia only, are as a rule cured by spectacles with convex lenses. Much benefit is also derived from powdered Secale Cornutum (5 to 10 grains to be taken four times daily) with some carbonate of magnesia or of iron.

Apparent *not true* Asthenopia.

The patients when reading, &c., or even when looking at distance, complain of the eyes aching and "watering," of pain in the ciliary region, and sometimes at the back of the eyes. The pain may be permanent and increase when attempting to work. In most cases this is accompanied by a sensation of tension over the eyebrows, and in many by smarting of the eyelids, by photophobia, and occasionally by phosphenes. The symptoms may increase to an extent that even going about in bright light becomes impossible.

Dimness of vision may accompany these symptoms, but it is the pain, &c., which compel the patients to desist from work often for months.

Apparent asthenopia occurs often in myopia, and occasionally in hyperæmia of the optic disc and retina. It is termed hyperæsthesia of the retina if no organic changes are discoverable.

The asthenopia arising from weakness ("insufficiency") of the internal recti muscles, by some termed *Muscular Asthenopia*, is often met with together with accommodative asthenopia. Sometimes it is mistaken for it. (See Insufficiency.)

Treatment.

Asthenopia, whether true or apparent, is a symptom which as a rule subsides under proper treatment of its cause. (See the treatment of Hypermetropia, Astigmatism, Myopia, Insufficiency, Paresis.)

Vision of Hypermetrops.

In the slighter degrees of hypermetropia vision is generally acute, and difficulties arise, not from any anomaly of the retina, but from exhaustion of the accommodation. The usual complaint is, that very small type cannot be read, that large type can be seen with greater ease when held further from the eyes, and that after having been reading or working for some time, the letters or objects become confused or disappear altogether. After rubbing the eyes, or closing, or resting them for a short time, work can be continued.

These are symptoms of asthenopia.

In high degrees of hypermetropia (of $\frac{1}{8}$, $\frac{1}{6}$, and more) the acuteness of vision is rarely perfect, and asthenopia appears sooner. The cause of this in some is astigmatism; in others it must be attributed to congenital anomalies of the retina or optic nerve. Occasionally we meet with hypermetropia in which the optic disc and retina, as far as ophthalmoscopic appearances go, appear quite healthy, though vision is reduced to perception of shadows, or only $= \frac{1}{200}$ or $\frac{1}{100}$.

The acuteness of vision may still be called perfect, if, with the assistance of convex lenses, it can be made to reach that of the normal eye; e. g. if No. I. can be read at 1 ft, No. VI. at 6 ft, No. XX. at 20 ft, &c.

If one eye is highly hypermetropic, and the other but slightly so, the former, through not being used, becomes amblyopic. Rapid improvement of vision is often obtained when frequently practising the amblyopic eye alone, with convex lenses.

Treatment.

Most of the inconveniencies arising from hypermetropia can be removed by the use of spectacles with convex lenses. Persons who object to wearing spectacles have to put up with the inconvenience arising from the hypermetropia, but may be assured that, if no spectacles be worn, the acuteness of sight will not suffer at all, or only slightly. Hypermetropic persons often attribute the asthenopia to commencing amaurosis; their mind is much relieved by an explanation of the nature and course of these symptoms.

Few hypermetropics object to wearing spectacles, since, in most cases, they have only to be worn for "near work."

It is well, by paralysing the accommodation with atropia, to ascertain the absolute degree of hypermetropia. In persons engaged in business, or of nervous temperament, this may be dispensed with, provided we explain the nature of the case, and the necessity of having the spectacles altered, as soon as the symptoms of asthenopia reappear.

The objects of wearing spectacles with convex lenses are,—to remedy the faulty refraction arising from the abnormal shape of the eye,—to prevent the power of accommodation from being used unnecessarily,—and to remove the asthenopia, and often the convergent strabismus.

Spectacles increase the region of accommodation by utilizing the power of accommodation which is used to obviate the effects of hypermetropia.

A hypermetrop who, to see distant objects without effort of accommodation, requires spectacles with convex lenses of 10 in. focus, has therefore a manifest hypermetropia of $\frac{1}{10}$. His nearest point of distinct vision without the spectacles, lies at 20″ from the eyes, and he has a range, or power of accommodation, of $(\frac{1}{10} + \frac{1}{20})$ a little more than $\frac{1}{6}$. To overcome the hypermetropia he is compelled to increase the convexity of his crystalline lenses to an extent which is equal to the addition to each of the crystalline lenses of a convex lens of 10 in. focus. In this case a large quantity of power of accommodation is used to overcome the hypermetropia. The region of accommodation extends from 20 in. to ∞ (= infinite distance), i. e. objects placed at 20 in., and at any distance beyond 20 in., can be seen distinctly. To make useful the power of accommodation (of $\frac{1}{10}$), which is employed to overcome the hypermetropia, we give spectacles with convex lenses of 10-inch focus. With these distant objects are seen distinctly without effort at accommodation. The absolute power of accommodation has not become increased by the use of these spectacles, but the power which was wasted is made useful; and objects which are placed at about 6″ from the eyes can now be seen distinctly. Thus the region of accommodation, instead of extending only from 20 in. to a great distance (from 20 in. to ∞), extends, with the aid of spectacles, from 6″ from the eyes to ∞.

No spectacles need be worn as long as vision for distance is good, and no asthenopia complained of.

To find the proper spectacles we first ascertain the amount of manifest hypermetropia by placing the patient at 20 ft from the letters No. XX. If he cannot spell these at that distance, we direct him to walk slowly towards the letters, and to stop when he can spell them. We commence the trial with lenses at that distance. If both eyes are equal we try both eyes simultaneously. If he can only spell the letters with one eye, vision of the other being defective, we keep the defective eye closed during the examination of the other.

We then try whether, when looking through a convex lens (commencing e. g. with No. 60 convex), the patient can spell the letters; if so, we continue trying convex lenses until we have found the strongest with which this can still be done. Suppose the patient spells the letters of No. XX. at 20 ft, and can do the same with No. 40, 30, or 20 convex, but no longer with No. 18 convex, we infer that No. 20 is the strongest convex lens, which brings the rays coming from the letters of No. XX. to a focus on

the retina; and we advise spectacles with lenses of 20-inch focus to be used for both eyes for reading and other near work. These spectacles remove the manifest hypermetropia, and often allow the patient to continue work for several years without fatigue.

We must insist upon the spectacles being altered as soon as the eyes become fatigued at work; e. g. suppose in the above case spectacles with 20 in. convex to have been worn for two years, after which time asthenopia appears again. We again determine the strongest convex lens with which the patient can now spell letters of No. XX., at the distance at which he can spell them without the lens. Suppose we find No. 16 to be the convex lens, we order the patient to have the 20-inch convex lenses removed, and 16-inch convex lenses inserted into the same spectacle frame. These spectacles are to be used for reading, &c., as before, until symptoms of fatigue again appear.

All hypermetropia becomes apparent ("manifest") *as age advances*, and the power of accommodation becomes less. Therefore at the age of 40, 45, or 50, the spectacles need no longer be changed as far as the hypermetropia is concerned. At that age presbyopia must be taken into account. (See Presbyopia.)

In our patient, who commenced with 20 convex, we may find that, all hypermetropia having become manifest, he recognizes the letters of No. XX. at 20 ft with 10 convex. Now in this case, if it had been desirable at the time when spectacles with No. 20 convex lenses were ordered, to know the degree of absolute hypermetropia (i. e. not only the manifest, but also the latent hypermetropia), we should have found, after paralysing the accommodation with atropia, that the absolute hypermetropia amounted to $\frac{1}{10}$.

The patient, when beginning to wear spectacles for work, should at first only use them for half an hour at a time, frequently during the day. In about three weeks later he may use them continually during the day, and some weeks later, also at night.

If the spectacles do not suit, and on inquiry we find that the patient, when reading, gradually brings the book nearer and nearer, because he cannot see the letters distinctly at the distance at which the book was held at first, we should ascertain :—

(1.) Whether the range of accommodation (considering the age of the patient) is normal. If so, we act on the supposition that the accommodation (the contraction of the ciliary muscle) is still too strong. This is the result of habit, the patient not having worn spectacles, or not the proper kind. The patient, although the spectacles remedy the latent hypermetropia, involuntarily exerts the accommodation too much. Vision thus becomes indistinct, and the book, to obviate this, is brought nearer and nearer. "The eyes ache" partly from undue contraction of the ciliary muscle, partly from the effort which the internal recti muscles have to

make to maintain the convergence of the eyes, which is necessary for reading when the book is held too close. In such cases we at first try spectacles with convex lenses, e. g. in manifest hypermetropia of $\frac{1}{10}$ we prescribe, instead of No. 20 convex, No. 30 convex for reading. These spectacles are to be used for all near work. The work should be interrupted frequently to rest the eyes, and also as soon as the desire arises to bring the work nearer to the eyes. In this way the action of the ciliary muscle (the accommodation) is gradually regulated. We give stronger lenses, and proceed as directed above, as soon as near work can be performed without fatigue.

Such cases appear to recover more rapidly by wearing the spectacles at first continually, which assists the efforts at accommodation for all distances.

(2.) Whether there is insufficiency. (See Insufficiency and Anomalies of Accommodation.)

If one eye is amblyopic it should be practised daily for from 10 to 20 minutes (the fellow eye being kept closed during the time), by making the patient use that convex lens as an eye-glass with which he can best recognize letters. A rapid improvement of vision is generally obtained.

MYOPIA (=M).

(*Short sight. Brachumetropia.*) (See Plate VIII. figs. 21, 22.)

In many of the modern books on Ophthalmology we still find it stated that myopia is the result of too great refractive power of the cornea and lens, by which the images of objects are formed in front of the retina.

A faulty state of the light-refracting portions of the eye is supposed to be the cause of myopia.

Dissections, measurements, and ophthalmoscopic examination have, however, shown that in nearly all cases of myopia the light-refracting parts are normal as regards their curvature, but that the retina and the adjoining tunics lie at too great a distance from the cornea and lens. The principal focal distance of these (the dioptric system) thus comes to lie in front of the retina.

No doubt cases occur in which myopia arises from too great convexity of the cornea (as in conical and globular cornea); or from displacement, or too great convexity of the lens, e. g. during spasm of the ciliary muscle.

We shall here speak of the myopia which is the result of anomaly in shape of the eyeball, and with it, in the positions of the tunics (sclerotic, choroid, and retina).

This anomaly is the opposite to the one observed in hypermetropia, and consists in an undue extension of the tunics, especially round the optic

nerve, and in the region of the yellow spot. If in the latter part the extension is unusually great, it is described as posterior staphyloma (staphyloma posticum). The hypermetropic eye is small (short from before backwards); the myopic eye is enlarged, or elongated (long from before backwards, egg-shaped). Connected with this abnormal shape are alterations in the tunics and in vision, and a series of morbid changes.

The diagnosis of myopia is made by means of the ophthalmoscope. With it we readily recognize the abnormal shape of the eyeball, and the alterations of the tunics, especially round the optic disc, and in the region of the yellow spot. In this we are assisted by the state of vision, and by the trial with concave lenses.

Examination with the Ophthalmoscope.

An observer, with normal eyes can, *by direct examination* with the ophthalmoscope, recognize the shape of every eye, whether too short, normal, or too long, as long as the optic disc is visible. (See Refraction.) He can, after some practice, by this means even determine the average degree of the myopia.

The sooner, during direct ophthalmoscopic examination, the well-defined outlines of the inverted image of the optic disc of the myopic eye (under the influence of atropia) appear indistinct, when approaching the eye from the distance at which they were seen distinctly with the ophthalmoscope, the higher is the degree of the myopia. In slight degrees of myopia (of $\frac{1}{30}$ and less) the erect image can also be seen; in the higher degrees, a concave lens, strong enough to neutralize the myopia, must be placed behind the sight-hole of the ophthalmoscope.

The indirect ophthalmoscopic examination is conducted in the usual way.

The optic disc of the myopic eye generally appears small; it appears larger if a convex lens of from 6-inch to 10-inch focus is placed behind the sight-hole of the ophthalmoscope. While holding the convex lens, as usual during examination of the inverted image, we approach the eye up to from two in. to three in., while looking through the sight-hole of the ophthalmoscope and through the convex lens behind it, we perceive the magnified inverted image of the optic disc.

The different parts of the myopic eye are examined as is usual in ophthalmoscopic examination, particular attention being paid to the outer margin of the optic disc when examining the erect, and to its inner margin when examining the inverted image.

Alterations of the Tunics.

The following description of the alterations of the tunics of the myopic

eye is the combined result of dissection, and of ophthalmoscopic examination.

The abnormal shape of the myopic eye (of the curvature of its tunics; especially of the part which extends from the outer margin of the cornea towards the optic nerve) is as readily perceived as that of the hypermetropic eye. By directing the myop to turn the eyes in different directions, we readily observe the abnormally great distance which exists between the margin of the cornea and the region near the optic nerve. Combined with this, we find a too slight curvature of the sclerotic. (See plate II., figs. 7, 8.) Generally all diameters of the myopic eye are enlarged, but, as a rule, chiefly the diameter from before backwards. The sclerotic in the region of the yellow spot appears bluish and thinned (see plate II., figs. 9, 10) if the distension of the tunics in that part is very considerable. In some cases it has been found nearly transparent. Inflammation may cause this part to become swollen and œdematous, and to appear thicker than other parts of the sclerotic. This, however, is a very unusual occurrence. The most bulging part of the tunics often corresponds to the region of the yellow spot, or lies somewhere between this spot and the nearest margin of the optic disc, and may project as much as 2‴ beyond the general curvature of the sclerotic. The distension round the optic disc may be very considerable without there being any circumscribed protrusion of the eyeball at all. The antero-posterior diameter of the eye has in some cases amounted to from 14‴ to 15‴, and the transverse diameter to from 10‴ to 12‴. Corresponding to the externally perceptible anomalies of curvature and of colour of the sclerotic, we find alterations in *the Choroid*, *the Optic Disc*, *and the Retina*.

The Choroid.

In this tunic changes occur which, once seen with the ophthalmoscope, can hardly be again mistaken. The changes are those of atrophy, preceded by hyperæmia. They are the results of distension, and are most conspicuous in the choroid on account of great alterations in its colour. The signs of atrophy become more conspicuous as the myopia advances. They are often visible at birth. They indicate progress of the myopia if they are considerable near the crescent, and if they shade off into the healthy choroid. About the age of 40 the atrophy becomes more conspicuous, and its boundary more irregular.

With the ophthalmoscope we first look for the optic disc, and for the tunics immediately adjoining it; then for the region of the yellow spot; and lastly, we inspect the more peripheral parts of the choroid.

The Optic Disc and the Tunics immediately surrounding it. (See plate VIII., figs. 21, 22.)

In nearly all myopic eyes we find a white figure, which in most has a crescentic form, and is termed "*the crescent.*" The crescent joins the portion of the margin of the optic disc which lies nearest the yellow spot. When examining the inverted image we, of course, see the crescent on the (inner) nasal side of the optic disc. The convex side of "the crescent" is directed towards the region of the yellow spot. The crescent varies in size. The rule is that it is the broader, i. e. its axis the longer, the higher the degree of myopia. When it extends all round the optic disc, or more in some directions, it loses the crescentic shape, and changes into an irregular white figure, which, however, in all cases is broadest towards the region of the yellow spot. In high degrees of myopia it may reach to, or even pass beyond, this spot. Its white colour is caused by the sclerotic shining through the atrophic choroid. The more clearly the white sclerotic is visible the higher is the degree of atrophy.

The colour of the crescent may be varied by blood in the vessels of the choroid, or by portions of choroidal pigment. Minute examination of the transparent atrophic portion of the choroid (of "the crescent") shows that it is thinnest where it joins the optic disc, and that, though atrophic (deprived of its pigment and capillaries), it can be traced up to the margin of the disc. Traces of the walls of the large blood-vessels are frequently found in it.

The term *Staphyloma posticum* is applied to the thinned portion of the tunics if it project towards the orbit beyond the general curvature of the eyeball.

The boundary of the crescent, if sharply defined by the natural colour of the choroid, indicates that the myopia is not progressing, or but slightly.

Atrophic changes in the part of the choroid adjoining the crescent are observed in increasing myopia.

Such atrophic changes are, in fair persons, a light red colour of the choroid, which is most marked along the crescent, and does not entirely mask the larger choroidal vessels. These vessels stand farther apart than in the healthy choroid. In persons with strongly-pigmented choroids ("in dark persons") the pigment spots along the crescent are particularly well marked.

On minute examination of the atrophied parts, we find alterations in the stellate pigment cells of the choroid.

The cells become paler even sooner than the granules of the hexagonal cells, e. g. from a deep brown they change into a pale yellow colour, and finally disappear. The pigment molecules disappear before the cells. The changes of atrophy in the choroid are most advanced where the thinning

of the tunics is most considerable. The walls of the hexagonal cells disappear; their pigment granules are scattered about as groups of brown or black spots, or as solitary brown granules.

Alterations in the blood-vessels of the choroid.—The large veins near the atrophic parts are filled with blood, and are broad. They do not stand so wide apart as those in the more atrophic and distended portions. An uniform red colour of the choroid round the atrophic parts, compared with that of less distended and more distant portions, is a sign of hyperæmia of the choroid, which often precedes atrophy.

Alterations in the optic disc. The optic disc, like the adjoining distended tunics, is pushed backwards and displaced towards the inner wall of the orbit. Its position is altered.

In the healthy eye the tunics are thickest round the optic nerve ("round the optic disc"). The attachments of the nerve to the tunics are particularly strong. In the myopic eye the tunics, especially at the outer margin of the optic disc, and in high degrees of myopia all round the nerve, are abnormally thin.

A fibrous sheath surrounds the optic nerve in the orbit, which on reaching the sclerotic becomes firmly attached to the latter; its fibres mix with those of the sclerotic. This sheath is separated from the optic nerve, or, properly speaking, from the fibrous tissue which immediately surrounds the nerve fibres, by loose connective tissue. Those fibres of the fibrous tissue, which immediately surround the optic nerve fibres and which lie nearest the tunics, are attached to and pass into the choroid, and into the outer margin of the sclerotic aperture. The tunics as well as the fibrous tissue of the optic nerve joining them, become distended at this spot; and it is here, and especially on the side nearest the yellow spot, that the distension and thinning become apparent in the choroid as "crescentic atrophy." The greater the distension the more does the optic nerve recede from the distended margin of the sclero choroidal aperture. The sheath of the optic nerve is connected loosely with the nerve, but firmly with the sclerotic, by connective tissue. The more the portion of fibrous tissue which connects the disc with the choroid and sclerotic becomes distended, the more does the optic disc recede, and the larger becomes the space (crescent) between the disc and the tunics. The loose connective tissue, which intervenes between the nerve and its sheath, does not oppose the distension. The tunics adjoining the "crescent" also become distended.

The optic disc, as a rule, appears smaller than that of the emmetropic eye. The curvature of its surface on the side adjoining the "crescent" is flat, or may be cupped. It is unusually convex on the opposite side. The shape of the disc is frequently oval, the long axis of the oval being vertical. The optic disc may in reality be round but appear oval: (1.) If, through great distension of the tunics and of the attachments of the disc, it is much

displaced towards the inner wall of the orbit; it is then seen more sideways, when viewed, e. g. with the ophthalmoscope. (2.) If the choroid and retina, opposite the distended margins, encroach upon the disc.

The optic disc rarely has the natural pink colour throughout. Often it is too red (a hyperæmia which generally accompanies rapidly-progressing myopia), or it has a greyish pink colour. Frequently we find that portion of the optic disc anæmic, which joins the most distended and atrophic part of the tunics, while the rest of the disc has a pink colour.

The vessels of the retina, where they pass through the optic disc, are rarely quite like those of the emmetropic eye. They are too numerous in rapidly-increasing myopia. The veins are tortuous and full. In all cases their course differs in the more distended parts of the optic disc and retina from that in other parts. In the distended parts of the retina they stand farther apart, and follow the curvature of that tunic. If the boundary of the distended part is abrupt, the abrupt curve of the vessels from it on to the more normally-curved parts of the retina is very conspicuous.

The region of the yellow spot is not only distended, but also somewhat displaced towards the inner wall of the orbit. The distension, as round the optic disc, is accompanied by changes of structure (atrophic changes). These are most conspicuous in the choroid. The many apparent varieties of atrophy chiefly depend on the tint of the pigment, and on the degree of distension.

Irregular light and dark brown spots (groups of stellate pigment cells); bright red or whitish spots, and in extreme cases well-defined white spots or fissures (transparent portions of choroid, devoid of blood and pigment) may be found. In rare cases we find the atrophic changes far advanced and well marked in this region, while round the optic disc they are less conspicuous, or separated from the disc by a more healthy-looking portion. Generally however the atrophy at the outer margin of the optic disc merges into that of the region of the yellow spot, where it is less conspicuous, from the choroid being more richly pigmented.

Degree of Myopia.

Myopic persons see distinctly only at certain distances. The farther the retina lies from the cornea and lens (from the dioptric system) the shorter is that distance, i. e. the nearer the eyes lies the farthest point of distinct vision. Beyond that distance objects appear confused, or are not visible at all.

The degree of myopia is known if the distance ($=$R) of the farthest point of distinct vision ($=$ r) from the nodal point (from the point within the eye where the refracted rays cross each other) is known. If the

farthest point of distinct vision lies at 10 inches the myopia is $\frac{1}{10}$, if it lies at 5 inches the myopia is $\frac{1}{5}$, &c.

To determine the farthest point of distinct vision accurately we make use of concave lenses. The rays which come from objects situated at the farthest point of distinct vision are still sufficiently divergent, after refraction by the cornea and lens, to be brought to a focus in the retina. Rays of less divergence, i. e. coming from objects farther distant than the farthest point of distinct vision, must, by the aid of some concave lens, be made more divergent to bring them to a focus in the retina. The weakest concave lens, which gives sufficient divergence to parallel rays (i. e. to rays from very distant objects) to cause them, after refraction by the eye, to be brought to a focus in the retina, expresses the degree of myopia. To find this lens quickly we ascertain the farthest point at which the patient can read ordinary type. Suppose he reads type No. I. at 10 inches and not farther, we first try No. 10 concave; if he reads No. I. at 5 inches we first try No. 5 concave, &c. This lens, or one a little stronger, or a little weaker, is, as a rule, the one which most improves vision for distance. We try both eyes at the same time, if both are equally myopic.

If one eye is more myopic than the other, we must find the concave lens which exactly suits each eye separately, beginning with the less myopic eye. If, with the concave lens, the patient spells the letters of No. XX. at 20 ft, of No. XL. at 40 ft, &c., we have not only ascertained the degree of the myopia, but also the acuteness of vision. Very often in high degrees of myopia the acuteness of vision is imperfect.

A myopia of $\frac{1}{10}$ ($=$ M $\frac{1}{10}$) means a myopic eye, which requires a concave lens of 10-inch focus for seeing at distance as acutely as the emmetropic eye does without artificial means.

The highest degree of myopia on record is one of $\frac{1}{1\frac{1}{2}}$, i. e. one requiring a concave lens of a little more than 1-inch negative focal distance.

For practical purposes, when speaking of the treatment of myopia by spectacles, a myopia of $\frac{1}{20}$ is termed one of slight degree; a myopia of $\frac{1}{10}$ one of moderate degree, and a myopia of $\frac{1}{5}$ one of high degree.

In the treatment of intermediate degrees of myopia (of those exceeding $\frac{1}{5}$, e. g. $\frac{1}{3}$; and those slighter than $\frac{1}{20}$, e. g. $\frac{1}{30}$ or $\frac{1}{40}$) we must be guided by the rules laid down for the treatment of slight, moderate, and high degrees of myopia.

Cause and progress.—The cause of the myopia is found in the too great distance of the retina and of the adjoining tunics from the dioptric system (from the cornea, lens, &c.). The abnormal position of the tunics is the result of distension and of increased curvature, especially round the optic disc, and in the region of the yellow spot.

The diminution of the natural thickness and curvature of the tunics is congenital.

The eyes, like the rest of the body, increase in size up to a certain period of life. In the myopic this is accompanied by a more or less rapid increase of myopia, which is chiefly promoted by the nature of the work which the eyes have to perform.

During reading and other "near work" objects have to be held close. The great convergence of the eyes is accompanied by pressure of the muscles upon the eyeball, and generally by stooping with increased accumulation of blood in the eyes. The tunics, especially round the optic disc and in the region of the yellow spot, are naturally weak in the myop, and their curvature becomes increased, and their structure altered. This alteration occurs in every myopic eye, and makes itself most felt between the ages of 15 and 25. Its chief symptom as regards vision is an increase of the myopia. In many patients this increase is accompanied by what are termed symptoms of irritation. These may go on to inflammation. They are generally coupled with a more rapid increase of the myopia, though in rare instances myopia may rapidly reach a high degree without symptoms of irritation.

An increase of myopia with changes in the tunics is observed in every myopic eye. In some the progress is rapid, in others almost imperceptible. Slight degrees of myopia may become changed into extreme ones, while high degrees may increase but slowly: the rule is that the myopia increases more rapidly if it has already reached a high degree before the age of 20.

Many myopic persons pass through life without ever wearing spectacles, and without experiencing inconvenience from their myopia, and retain excellent sight for reading and near work. Experience, however, has shown that myopics who wear spectacles throughout life are much less exposed to the morbid changes which at some period or other may make the myopic eye very troublesome, and in many instances useless.

Of these morbid changes the most frequent are:—Symptoms of irritation, muscæ volitantes, and sudden or rapid impairment of vision.

Vision of Myopics.

The rays coming from objects which are placed beyond the farthest point of distinct vision of the myopic eye are no longer brought to a focus in the retina. The objects appear ill-defined, but are seen more distinctly by "screwing up" the eyelids so as to narrow the palpebral aperture and the pupil; and some myopics thus very much improve their vision for distance. The same occurs if the size of the pupil becomes diminished, as in advanced age.

The acuteness of vision is normal if the myop, with the aid of a concave lens, can read the test types at the normal distance, e. g. No. I. at 1 ft,

No. II. at 2 ft, &c. The myop sees small objects better, because he can bring them closer to the eyes, and therefore sees them under a greater angle. With this is connected his being able to work, read, &c., with less light than others. The acuteness of vision in the highest degrees of myopia is generally imperfect, so that in a myopia of $\frac{1}{5}$ No. I., instead of being read at 5 inches, can only be read at 3 inches, or not at all.

We often find one eye more myopic than the other, or in rare cases only one myopic, the other emmetropic, or even hypermetropic. One eye is often used for reading, the other for distance.

Diminution of acuteness of vision.—Some myopics state that vision at no time of life was comfortable; that symptoms of irritation, difficulty in recognizing objects, &c., always existed more or less. In these we must expect to find some congenital anomaly, besides the myopia, as cataract, displacement of the crystalline lens, or a troublesome degree of astigmatism of the cornea.

Impairment of vision, accompanied by symptoms of irritation, generally appears during rapid growth of the body.

Acuteness of vision, as age advances, decreases more rapidly in the myopic than in the normal eye, e. g. in a myopia of $\frac{1}{4}$ it may, at the age of 60, only amount to $\frac{1}{3}$, while in a normal eye of the same age it is nearly twice as great. The distension of the retina, together with that of the other tunics (especially in the region of the yellow spot), if it goes beyond a certain point, is the cause not only of rapidly-increasing myopia, but also of amblyopia. The elements of the retina, displaced or destroyed by distension of the tunics, &c., cease to act, and patients complain of "scotomata." (See Scotomata.)

The scotomata are most troublesome if situated at or near the yellow spot. The patient while reading complains of glimmering, or quivering of the letters, which come to stand alternately opposite sensitive and more or less damaged parts of the retina. The complaint of not seeing some words of a sentence, or some letters of a word, is generally explained by morbid changes in corresponding parts of the retina. Small letters or objects can be seen, while larger objects are less readily recognized, in consequence of parts of them coming to lie opposite impaired portions of the retina.

Other causes of impairment, or loss of vision are:—Atrophy, Displacement of the retina, Effusion of blood, and Glaucoma. (See these subjects.)

Impairment of the function of the part of the retina which joins the outer margin of the optic disc is, on examintion, often observed in myopia, though it rarely attracts the patient's attention unless it encroaches upon the region of the yellow spot. In the latter case patients complain of a dark spot (by some described as having coloured margins), which obscures the part of an object situated outwards from the point of the object directly looked at.

The size of the impaired portion of retina sometimes corresponds exactly to the size of the crescent, but generally only partly so, and depends upon the destruction of the retina adjoining the atrophic choroid.

The optic nerve fibres, passing over the impaired portion of retina, are intact, since retinal impressions, formed beyond the blind part, are perceived.

Cataract is a frequent complication of myopia. Not the uniform grey and opaque kind, but the one which appears as minute white dots, or as polar cataract, or commences with narrow striæ appearing at the margin of the lens, and leaving the rest transparent sometimes for years.

Partial, or total spontaneous dislocation of one, or generally of both lenses has repeatedly been observed.

Muscæ volitantes.—The abnormal condition of the tunics surrounding the vitreous chamber, and the changes to which the "vitreous" itself is subject during distension of the tunics, are the causes why most kinds of muscæ may be met with in myopic eyes. (See Vitreous Substance.) The muscæ often appear suddenly, and without any signs of irritation. They are too small to be visible with the ophthalmoscope, and are connected with morbid changes of the "vitreous."

Not unfrequently we meet with partial displacement of the hyaloid membrane, fluid intervening between it and the retina. On careful examination with the ophthalmoscope, we may succeed in seeing the displaced part. It appears as a transparent fold of membrane, which, in a limited area, floats to and fro in front of the retina. It is distinctly perceived by the patient as a dark, slightly movable spot, and has repeatedly been found on dissection.

The "vitreous substance," though free from muscæ, frequently loses its consistence, and becomes more or less fluid, either throughout, or only adjoining the most atrophic portions of the tunics. Under such circumstances it often gives rise to "tremulous lens and iris." (See Vitreous Substance.)

Photopsia greatly distresses many myopic persons for years, without giving rise to any impairment of vision. It may be intermittent or persistent, and is most troublesome in the dark. The patients generally complain of red flashes of light, or of red spots appearing before the eyes. Several patients repeatedly have stated that when the flashes appear suddenly objects situated externally to the eyes could be recognized during the duration of a flash.

Hyperæmia of the optic disc accompanying the distension, &c., of the adjoining tunics, and unusually rapid atrophy and distension of the hexagonal cells affecting the rods and bulbs, are probably the sole cause.

If the photopsia appears suddenly, and simultaneously with amblyopia, it must not be treated lightly. Partial displacement of the retina, or

inflammation of some parts of the tunics, may be the cause, and must be looked for.

Treatment.

The functions of the myopic eye, as regards acuteness of sight, are most frequently impaired by undue distension of its tunics.

Our advice must tend as much as possible to diminish the progress of the distension, i. e. the increase of the myopia. We therefore recommend the patient:—

Not to stoop when reading, &c. Especially strongly myopic persons, as a rule, stoop when reading, &c., and hold objects nearer than is necessary for distinct vision. They must, to do this, converge the eyes strongly if both are used.

Stooping gives rise to congestion of the eyes, to increase of tension, and, through too great convergence, to pressure upon the already too thin coats of the eyeball. Patients should hold the head upright when reading, and place the book or paper, when writing, on a sloping desk. Particular attention should be paid to this in children. Objects must be held as far from the eyes as is compatible with distinct vision, and, if that distance is less than ten inches, spectacles may be recommended in young myopics.

Complaints of weakness, fatigue, pain, irritability, &c., of the eyes.

These symptoms are termed symptoms of irritation. They may appear during near work, e. g. reading only. Often they are present, whether looking at near or at distant objects. They are connected with hyperæmia of the external and internal parts of the eye, as observed in the course of progressing myopia (distension of the eyes). Close application to study, or to other near work during rapid growth of all parts of the body, seems to be the most common cause of these troublesome symptoms. They very rarely rise to actual inflammation.

The patient complains of intolerance of light, which may be very great and continue for months—of watering of the eyes—and of aching, or of actual pain over the eyebrows, and "at the back of the eyeballs." The pain may be caused by the hyperæmia and distension of the tunics, or by spasm of the ciliary muscle. In the latter case we often find the portion of the tunics, which lies over and near the ciliary muscle, tender to the touch, and the pain increase rapidly during near work. The eyes often continue sensitive to light and touch after all near work has been discontinued. Rarely do we hear the common complaint of hypermetropics of the letters running into one another, or disappearing, after reading for some time (= asthenopia).

It is generally the aching, the weakness, the "dazzling," and the

intolerance of light which compel the myop to discontinue near work, and in high degrees even to abstain from moving about in bright light. Frequently the complaint is made that, after reading for some time, one eye "moves outwards," that the words seem to move over each other, and that efforts to overcome the outward movement are painful. This symptom is attributed to insufficiency of the internal recti muscles.

On examination with the ophthalmoscope we find sometimes the entire optic disc hyperæmic, sometimes only the portion which joins the least distended parts of the tunics, while the one next the crescent appears anæmic. In many cases it appears as if the retina (the retinal aperture) encroached upon the optic disc, i. e. as if it were drawn over the margin of the disc by the distended portion on the opposite side. The optic disc, choroid, and retina at that spot are particularly hyperæmic.

The veins of the retina are often very tortuous and full over the distending portions of the tunics. Sometimes the retina is not quite as transparent as in other parts. The choroid adjoining the transparent atrophic portions appears unduly "red" and its veins gorged with blood.

The margins of the eyelids appear somewhat reddened; thin, "delicate" myopics frequently suffer from slight tinea. The sub-conjunctival vessels, emerging from the sclerotic near the margin of the cornea, are numerous; and the pupil, in higher degrees of hyperæmia, is sluggish. In high degrees of irritation a rapid increase of myopia, amounting in some cases to amblyopia, is observed.

The patient must abstain from the kind of work which brings on the symptoms of irritation; and should never work longer than can be done with comfort. The better this rule is observed the shorter will be the period during which reading, &c., need be prohibited, and the less rapid will be the progress of the myopia.

Spectacles with blue tinted large round glasses, the tint being selected which feels most pleasant to the patient, should be worn. They must be laid aside if light is no longer troublesome.

The aching and pain are often permanently relieved by tinted spectacles and the frequent use of atropia.

Leeches (from 6 to 12) are applied to the skin of each temple at bedtime, and both eyes are carefully kept closed for 48 hours after the leeching, if the pain is severe and not soon relieved, though the patient have worn tinted glasses, used atropia, and abstained from near work;—or if a rapid relapse of pain, &c., occurs. In actual inflammation (choroido-retinitis) the artificial leech is preferable; with it a large quantity of blood can be obtained in a very short time. In some cases as much as 40 ounces of blood have been abstracted within two hours. The patient must be kept in a dark room for two or three weeks. The transition to light must be gradual.

Other means which may be recommended to prevent or remove symptoms of irritation are:—rest; keeping the head, when lying down, well raised, and the feet warm; much sleep before midnight; the eye-douche (made by Mr Durroch, of St Thomas's Street, Southwark). Many myopics prefer tepid water, others select tepid water in the morning and cold water at bed time. The douche may be used for from 10 to 15 minutes at a time, and as often as convenient. The best times are after breakfast (using tepid) and at bed time (using cold water).

No spectacles with concave lenses should be allowed for near work as long as symptoms of irritation persist. If these are slight, spectacles with slightly tinted concave lenses may be worn for walking, or for distant vision only. The irritation having subsided, we recommend continuation of the general hygienic measures, and prescribe the necessary spectacles for reading, &c. Their use must be discontinued at once if they give rise to irritation.

Besides attending to the symptoms of irritation, we must ascertain whether insufficiency of the internal recti muscles exists. The latter is a fertile source of impairment of vision. (See Insufficiency, and Divergent Strabismus.)

If the patient complains of scotomata, corresponding to which we discover atrophic changes in the choroid and retina, no improvement of vision can be obtained, though loss of vision need not be feared.

Spectacles with concave lenses enable the myop to see distinctly at a greater distance.

Concave lenses increase the divergence of the rays of light. Rays, coming from objects situated beyond the farthest point of distinct vision of the myop, can, by the aid of concave lenses, be brought to a focus in the retina. Concave lenses also increase the region of accommodation. A myop, who without concave lenses sees distinctly from 3 in. to 10 in., has a region of accommodation of 7 in., and a myopia of $\frac{1}{10}$. With concave lenses of 10-inch focus the region of accommodation becomes very much larger, since with them objects can be recognized as well at 4 in. from the eyes as at a great distance.

The chief difficulty found especially by highly myopic persons (above $\frac{1}{10}$) in using spectacles with concave lenses (which make their "sight" equal to that of the "healthy eye"), is that the spectacles cause the nearest point of distinct vision for both eyes to stand too far off. The consequence is that, for reading or near work, the patient has not the necessary relative range of accommodation, i. e. the one which is required to maintain prolonged distinct vision at a certain convergence of the eyes. It is only by practice that the myop succeeds in altering the relative range of accommodation so that, with slight convergence, he can bring into play the power of accommodation which is necessary for easy vision with higher degrees of convergence.

When selecting spectacles with concave lenses the following points should be attended to:—

(1.) We should first determine the degree of the myopia; in other words, we should find the weakest concave lens which, held close in front of the cornea, gives the most distinct vision for distance, e. g. with which letters of No. XX. can be recognized at 20′.

In high degrees of myopia (if stronger concave lenses than $-\frac{1}{10}$ are required for distance) we should be particularly careful to ascertain the exactly suitable lens. We place the concave lens, which is thought best, close before the patient's eye, and alternately hold in front of it a weak convex and concave lens (say $\frac{1}{80}$ and $-\frac{1}{80}$). If e. g. of several convex or concave lenses, $-\frac{1}{80}$ held before $-\frac{1}{10}$ (this being the concave lens which at first was thought best), improves vision most, then $-\frac{1}{10}$ was too weak, and we give $(-\frac{1}{10} + -\frac{1}{80})$ about $-\frac{1}{9}$. If vision is most acute when $\frac{1}{80}$ is held before $-\frac{1}{10}$, then $-\frac{1}{10}$ was too strong, and we give $(-\frac{1}{10} - +\frac{1}{80})$ about $-\frac{1}{11}$.

In higher degrees of myopia especially, we must pay attention to the distance of the concave lenses from the eyes. A concave lens makes objects appear the smaller (i. e. displaces the nodal point the more towards the retina) the farther it is held from the eye.

A concave lens held at 1 in. from the eye acts as a stronger concave lens than if it is held at $\frac{1}{2}$ in. from the eye; and at $\frac{1}{2}$ in. from the eye it acts as a stronger concave lens than if it were placed immediately upon the crystalline lens within the eye, e. g. in myopia of $\frac{1}{10}$ a concave lens of 10-in. focus held at $\frac{1}{2}$ in. from the eye, acts as a concave lens of $9\frac{1}{2}$-in. focus. If, therefore, we order spectacles with concave lenses, the negative focal distance of which is greater than 10 in., we must consider the distance of the lens from the eye.

(2.) If both eyes are equally myopic, or nearly so, we should give lenses of equal strength.

(3.) If one eye is more myopic, the difference between the two being slight (one requiring, e. g. $-\frac{1}{30}$, the other $-\frac{1}{40}$), we should find the lens which is best suited for the least myopic eye, and give the same for the other eye. If the difference of myopia is great, e. g. if one eye requires $-\frac{1}{5}$, the other $-\frac{1}{10}$, we may partly correct the difference of refraction by giving $-\frac{1}{5}$ to the one and $-\frac{1}{8}$ to the other eye. If this combination fails, we give the suitable concave lens to the least myopic eye and the same lens to the fellow eye.

Sometimes it happens that only one eye is used in reading, not through the retinæ being at fault, but through the converging power of one, or of both eyes being too weak ("insufficient"). In such cases, when using

spectacles for reading, the book being held at 10 in. or 12 in., we may find that the patient complains of fatigue after reading for some time, which fatigue ceases on excluding one eye. The spectacles have caused the eye, which previously to wearing spectacles was not used, to participate again in the act of reading, and also have caused the insufficiency of the converging muscles to make itself felt. In these cases the insufficiency must be attended to, as well as the myopia.

(4.) The "spectacles" are too strong, i. e. an undue amount of accommodation is used, if the patient states that looking through them makes distant objects appear smaller.

(5.) In high degrees of myopia, where spectacles had not been used until middle age, and in myopics suffering from symptoms of irritation, if we think proper to order spectacles with concave lenses, we should give those which allow the patient to see distinctly only at a limited distance. The lenses of these spectacles must be weaker than those which would completely remove the myopia. How much weaker depends upon the distance at which we wish the myop to see distinctly. If it is desirable that a myop, who for distance requires $-\frac{1}{5}$, should see distinctly only at 30 in. ("that his farthest point of distinct vision should be brought to 30 in."), we give lenses of $-\frac{1}{6}$ $(-\frac{1}{5} - (-\frac{1}{30}) = -\frac{1}{6}$. If the farthest point of distinct vision has to be brought to 20 in., we order $\frac{1}{6.6}$, $(-\frac{1}{5}) - (-\frac{1}{20}) = -\frac{1}{6.6}$. If that point has to be brought to 10 in., we order $-\frac{1}{10}$ $(-\frac{1}{5}) - (-\frac{1}{10}) = -\frac{1}{10}$.

No Spectacles need be worn—

If the myopia is slight, e. g. if with $-\frac{1}{20}$ the patient can read No. XX. at 15 or 18 ft. To see distinctly at distance an eyeglass which completely neutralizes the myopia, may be used.

Spectacles should be worn—

(1.) If the degree of myopia is higher than $\frac{1}{20}$, so that to read No. XX. at 20′, stronger concave lenses than $-\frac{1}{20}$, say $-\frac{1}{10}$ are required. In this case we order for distance spectacles with concave lenses, which at once completely neutralize the myopia, i. e. which make the patient read No. XX. at 20′.

(2.) The same spectacles may be allowed for near work if the patient is young, not more than 25; if there are no signs of irritation; if the degree of myopia amounts to about $\frac{1}{4}$ of the range of accommodation; and if the myopia does not exceed $\frac{1}{10}$ or $\frac{1}{9}$, i. e. if with $-\frac{1}{10}$ or $-\frac{1}{9}$ he can read XX. at 20′, and recognize letters when placed at about 4 in. from the eyes.

If the degree of myopia amounts to more than one-fourth of the range

of accommodation, or if the patient cannot read with ease with the spectacles which were given at first, we begin with weaker ones, e. g. with spectacles which enable the patient to read No. XX. only at 10 ft. After some time we give stronger spectacles, e. g. a patient with a myopia of $\frac{1}{10}$ would commence with spectacles with lenses of $-\frac{1}{20}$. After three months he may try lenses of $-\frac{1}{15}$, and three months later lenses of $-\frac{1}{10}$. If the spectacles with lenses of $-\frac{1}{10}$ give rise to irritation, those with $-\frac{1}{15}$ must be continued somewhat longer, &c.

If the patient (the myopia amounting to not more than $\frac{1}{9}$ or $\frac{1}{10}$) is of middle age, has never or only rarely worn spectacles, and wishes to have such for reading, we often find that signs of irritation appear if we give spectacles with lenses of $-\frac{1}{9}$, or of $\frac{1}{10}$ for reading, or even for looking at objects a few feet distant. The cause of this lies in the power of accommodation, which naturally has become less, not having been practised with spectacles. In these and similar cases we order spectacles which allow the patient to see distinctly at from 4 to 6 ft., and gradually increase their strength. In the myop of $\frac{1}{9}$, e. g. we begin with $-\frac{1}{14}$. Several years may pass before we can give spectacles with $-\frac{1}{9}$ for reading and for distance.

If the patient has an occupation which requires acute vision for a prolonged period at a given distance, we must find the spectacles which bring the farthest point of distinct vision exactly to that distance for which acute vision is required. Suppose our patient's myopia amounts to $\frac{1}{10}$, and we wish to bring the farthest point of distinct vision to 20 inches, we give spectacles which are $\frac{1}{20}$ weaker than those used for distance $(-\frac{1}{10}(-\frac{1}{20}= -\frac{1}{20}$, we give spectacles with lenses of $-\frac{1}{20}$.

If the myopia amounts to $\frac{1}{5}$, or more (if, e. g. $-\frac{1}{5}$ is required to read No. XX. at 20′), we give spectacles which bring the farthest point of distinct vision to about 15 in. Thus, if the myopia amounts to $\frac{1}{5}$ we give $-\frac{1}{8}$, with which the patient can see distinctly at about 15 inches. To see distinctly at a greater distance we order an eyeglass or a lorgnette, which, when held before the spectacles, should neutralize the myopia. In the above case spectacles with $-\frac{1}{8}$ being worn, the eyeglass to be used for distance would be one with a lens of about $-\frac{1}{15}$.

In high degrees of myopia (of $\frac{1}{5}$, $\frac{1}{4}$, or more), if the acuteness of vision is decreasing, we ascertain which is the less myopic eye, and for distance order an eye-glass which removes only part of the myopia (e. g. for myopia of $\frac{1}{5}$ we give an eye-glass with $-\frac{1}{10}$.) We ascertain whether, looking through a slit or small aperture, with and without the $-\frac{1}{10}$, improves vision for distance (holding the concave lens next the eye). We can, if there is considerable improvement, combine the slit and the $-\frac{1}{10}$ into a stenopæic eye-glass.

No reading or other near work should be allowed as long as loss of acuteness of vision and myopia are progressing rapidly, nor as long as there are symptoms of irritation.

It often happens that highly myopic persons use only one eye when reading. Such need not wear spectacles, since the danger arising from great convergence of the eyes does not exist. In such cases symptoms of irritation may appear if spectacles are given which bring both eyes into use while reading. Such myopics should carefully avoid stooping, use an eye-glass for distance, and no spectacles for near work.

Patients complain that "the spectacles make the eyes ache."

This occurs if the spectacles are not properly selected ("too strong"). (1.) Most frequently in myopics who had signs of irritation previous to using spectacles. (2.) In persons who have not worn spectacles until middle age; and (3), in some myopics who are advanced in life, and have worn spectacles continually.

No spectacles with concave lenses should be worn as long as the eyes are irritable. They increase the irritation, and the distension of the tunics, and with them the myopia. The irritation having subsided under proper treatment, we give at first spectacles with lenses which neutralize about one-half or one-third of the myopia, e. g. in myopia of $\frac{1}{10}$, we order at first spectacles with lenses of $-\frac{1}{20}$, instead of $-\frac{1}{10}$. These may be used for going about, and at short intervals frequently during the day, and for near work. No spectacles must be used, and all near work be discontinued for a time, if the habit of stooping or of bringing objects too near the eyes increases or continues, or if the myopia makes rapid progress, or if signs of irritation appear.

Myopic persons advanced in life (*above* 45 *or* 50) *become presbyopic*, and for near work require spectacles with weaker concave lenses; or, if the myopia is slight, with slightly convex lenses; others can lay aside the spectacles altogether, and perform all near work without them. We must remember that in myopics also power of accommodation and acuteness of vision become diminished as age advances. We should therefore be particularly careful, in selecting the lenses, to give those which bring the farthest point of distinct vision exactly to the point at which the patient wishes to see. (See Presbyopia.)

Acuteness of vision in older myopics often decreases rapidly within a few months. If in these cases we find no anomaly beyond the usual changes of the power of accommodation, and those of atrophy and distension in the tunics, we need not be alarmed. We prohibit near work for a time, and order leeches to be applied to the temple once a week for several weeks in succession.

SUPPURATION OF THE EYEBALL.

(*Ophthalmitis, Panophthalmitis.*) (See also Sympathetic Iritis, &c.)

Causes. (1.) Chemical and mechanical injuries (foreign bodies, pieces of metal, &c., lodged in the choroid or retina); operations for cataract, whether by extraction, depression, or absorption; wounds of the healthy crystalline lens; wounds of the cornea, followed by suppuration, the latter spreading to the iris, choroid, &c.

(2.) Pyæmia, puerperal fever, pericarditis, meningitis, fever, scarlatina, measles, and especially erysipelas. These causes often produce ophthalmitis of both eyes. The ophthalmitis appears, however, by preference in the eye which in some way previously may have been morbidly altered.

We must be prepared for the appearance of ophthalmitis if our patient complains of pain in one or both eyes, followed, in from six to eighteen hours, by chemosis, slight protrusion of the eyeball, with impaired mobility, loss of transparency of the cornea, iritis; and especially (if the pupil be clear) by the appearance of pus in the vitreous chamber, giving rise to a yellow reflection from behind the pupil, with concomitant rapid loss of vision.

The cornea, if the suppuration commences in it, e. g. round the incision after extraction of cataract, soon becomes opaque and yellow, and prevents a view of the iris, pupil, &c. It is important to observe that, in suppuration confined to the cornea, or cornea and iris, the perception of light and free mobility of the eyeball continue; not so in ophthalmitis. The cornea, or part of it, may remain transparent during the entire course of the ophthalmitis, if the latter commences behind the iris. Most frequently the lower half of the cornea suppurates, and, to the great relief of the patient, becomes perforated, allowing the pus, vitreous, &c., to escape.

The iris is always inflamed, discoloured, stiff, and vascular, and infiltrated with pus. Sometimes it is pushed forwards by blood or pus, or by a foreign body behind it. The pupil becomes closed and the aqueous humour discoloured by lymph. The other external signs and the symptoms complained of by the patient vary according to the cause and the stage at which we meet the ophthalmitis.

The lids and conjunctiva present appearances very similar to those observed in severe purulent ophthalmia. The lids become red and swollen. In ophthalmitis following general disease, e. g. fever, they may, however, retain an almost natural appearance. The watery and muco-purulent discharge which escapes from between the lids is slight, or may be altogether absent.

The loss or impairment of mobility of the eyeball is well marked in all

cases, and is partly caused by the action of the muscles being impeded by inflammatory changes in and round them.

The tension of the eye in some cases rises rapidly within a few hours from the commencement; in others it remains normal; in all it soon sinks below par. It is difficult to ascertain the tension on account of the swelling of the sclerotic.

The pain is generally severe if the ophthalmitis is due to external causes. It is frequently absent when ophthalmitis follows internal causes. Pain is one of the symptoms first complained of. It has the character of smarting and aching, or is dull and deep-seated. It is felt in the eye, and extends over the corresponding side of the head and face. It is worse at night, and unless surgical treatment be adopted, may continue for weeks.

Vision, unless the inflammation be arrested within thirty-six hours, is, as a rule, lost. Flashes of light, fiery circles, &c., rarely accompany the loss of sight.

Pathology.—The most striking feature of ophthalmitis is the rapid appearance of pus in the different structures of the eyeball. Suppuration in these parts is supposed to spread along the blood-vessels. The numerous connective tissue corpuscles, which surround especially the dilated capillaries of the choroid, are said to become changed into various forms of nuclei and cells (pus cells and exudation corpuscles).

The nuclei of these corpuscles are stated to increase in size, to subdivide, and to give rise to various forms of cells. The stellate pigment cells of the choroid take no share in this change.

Together with the pus appears an abundance of fluid, and of coagulable lymph, causing swelling and displacement of the tunics, with a series of other changes. The pus often escapes spontaneously by perforating the thinnest part of the sclerotic behind the insertion of one of the recti muscles, or it escapes through the cornea.

The appearance of the different structures, which suffer in ophthalmitis, varies according to the stage at which they are examined, and according to the degree to which they are implicated. The whole of the vitreous substance, or part of it, loses its transparency, becomes opaque, and assumes a yellowish or grey colour from accumulation of pus cells. These may be so numerous, especially near the crystalline lens, the yellow spot, and optic nerve, as to change the vitreous into an opaque yellow flocculent substance.

The vitreous becomes altered in consistence, and gradually shrinks. Blood-vessels appear in it among a more or less closely-woven network of connective tissue. The more fluid parts may escape by perforation, or become absorbed.

The choroid, ciliary processes, and ciliary muscle may be implicated simultaneously, or separately. They are altered in colour, and become

swollen through infiltration with serum, fibrin, and pus. These parts may however appear merely œdematous, while the retina is changed into a yellow and opaque (suppurating) substance. On the other hand, the choroid may be much swollen, yellow, and opaque, while the retina remains semitransparent and the vitreous chamber comparatively free from pus.

The choroidal vessels, surrounded by blood-spots, appear extremely dilated in some, and strangulated in other, places. The stellate pigment cells are lost sight of in the pus. The hexagonal cells ("choroidal epithelium") are changed in colour and altered in shape. They become round and swollen, and their granules are scattered about. Groups of these cells and of granules, in the shape of brown and irregular spots and patches, may be seen on the outer surface of the retina when drawing the latter away from the choroid. The choroid, deprived of those cells and granules, appears yellow and opaque.

In other cases no trace of the hexagonal cells remains; and the opaque and yellow choroid is found sprinkled with patches of enlarged capillaries, and with blood-spots.

The suppurating choroid undergoes changes similar to those of other tunics when in a state of suppuration. It shrinks, becomes atrophic, and more or less detached from the sclerotic. Spicules, or shells of bone, and of carbonate of lime, adhering to its inner surface, and cysts and fibrous bands in its substance, are often met with. Shrinking and contraction of the ciliary processes causes displacement of the ciliary muscle.

The retina at first loses its transparency, and becomes semiopaque. It may become transparent again, though most of its elements are destroyed. Generally, however, it remains more or less opaque. In some cases its outer surface is covered with a thick network of capillaries, and with numerous blood-spots, which gives it a crimson colour. In other instances this colour is observed on the inner surface of the retina, while the outer appears yellow and opaque. Portions of retina often become adherent to the choroid.

Minute examination of the suppurating retina shows that the rods and bulbs become swollen, and finally disappear. The fibres of the framework are sprinkled with minute granules. Numerous pus cells and granules are found among the elements of the retina. The retina finally is reduced to a semiopaque or transparent, thin, fibrous substance.

In most instances the retina, sooner or later, becomes detached from the choroid by changes of the vitreous substance. The fluid found between the choroid and retina is turbid and albuminous, and contains pus cells. At a later period we find in it a large number of granules, single or aggregated. The fluid often disappears completely while the shrinking of the tunics progresses.

The *course of ophthalmitis* much depends upon the cause. When following injury, it may reach its height in from twenty to thirty-six hours; fever, shivering, swelling of the lids, &c., and loss of vision appearing within that time. When the result of internal causes, it may arrive at its height in from two to six days.

In rare cases no warning is given of the critical state of the eye, beyond slight redness of the lids and some muco-purulent discharge. No hope of restoring useful vision is left when perception of light is once lost. The result must be considered favourable if, though vision be lost, the appearance of the eye is preserved.

The contents of the vitreous chamber, as a rule, escape through an opening in the suppurating cornea or sclerotic.

The discharge and the redness of the lids, conjunctiva, and sclerotic, often continue for two or three months, while the eye becomes reduced to an irregular "stump" (Phthisis bulbi). The lids become displaced and immovable by shrinking of the conjunctiva and orbital tissue if these parts have been much inflamed. In young persons (before the general growth of the body is completed) the orbit becomes perceptibly smaller, and the shape of the corresponding side of the face is altered. Pyæmia, meningitis, and death have, in a few cases, been the result of ophthalmitis alone.

Attacks of ophthalmitis may occur during successive confinements, destroying the eye completely after the second or third attack.

Treatment.—To preserve vision the ophthalmitis must be arrested at its very onset. Treatment is often successful if the ophthalmitis arises from external causes; but rarely if it follows measles, erysipelas, pleurisy, or other general causes.

For its symptoms and treatment when following the operation of cataract, *see* Cataract.

If caused by some foreign substance which is still suspected to be lodged in the deeper parts of the eye, the foreign substance should be carefully sought for, even at the risk of sacrificing vision. The removal of the foreign substance has often succeeded in arresting the suppuration, and in securing the safety of the fellow eye.

In strong patients, especially if suffering from severe pain, application of ice, or of pieces of lint dipped into cold water, over the closed lids, and of from six to ten leeches to the corresponding temple, may arrest the suppuration. The cold applications should be continued as long as may be pleasant to the patient.

The pain is relieved and the suppuration accelerated (all perception of light having been lost) by the use of warmth; by frequent bathing of the lids with warm Lotio Papaveris; by the application of poultices; and by puncturing the eyeball at the most depending part, or where pus seems to point.

Excision is performed if a foreign body, lodged in the eye, cannot be removed; if the pain does not subside under the above means; or if the sympathetic changes in the fellow eye do not yield to atropia.

As little as possible should be excised besides the eyeball, since the shrinking of the soft parts of the orbit in itself causes an unusual diminution of the tissue which is to support the artificial eye.

ABSCISSION OF THE EYEBALL.

The object of the operation of abscission is the removal of those parts of the eyeball which are situated in front of the ocular insertion of the recti muscles.

Instruments.—Stop-speculum, forceps, cataract knife, a pair of blunt-pointed scissors. Three strong, slightly curved needles, armed with fine silk or silver wire.

Operation.—The patient is placed as for excision, and brought thoroughly under the influence of chloroform. The lids are kept open by the stop-speculum to expose the eye sufficiently without pressing upon it. With forceps and scissors the conjunctiva is separated from the sclerotic, as far backwards as the insertion of the recti muscles.

The curved needles are then passed through the sclerotic and the other tunics, and through the vitreous chamber; partly to prevent the contents of the latter from escaping, partly to facilitate the union of the cut edges of the tunics.

The first needle is introduced just in front of the insertion of the outer rectus muscle, then carried across the interior of the eye, and brought out in front of the insertion of the inner rectus muscle. The second needle is inserted about $\frac{1}{6}$ inch above, and the third at the same distance below the first one.

Some difficulty is often experienced in bringing out the point of the needle at the spot intended. Attention to the direction of the curvature of the needle will assist in giving the point the right direction.

The needles having been inserted, we remove the part of the eye situated in front of them. The point of a cataract knife is thrust through the tunics into the vitreous chamber, just in front of the insertion of the upper rectus muscle. Through this opening one blade of the scissors is introduced, the other passing along the outer surface of the sclerotic. The rest of the incision is completed with scissors. The vitreous substance in front of the needles is removed last.

The incision being carried through all the tunics (from the insertion of the upper rectus along the points from which the needles project to a spot just in front of the insertion of the inferior rectus muscle), has a somewhat

elliptical form, which facilitates union. The middle needle is drawn through first and the suture tied, then the upper needle, and last the lower one.

Lint, dipped into cold water, is tied over the closed lids, so as to cause some pressure until straining and sickness are no longer likely to occur. The bandage is then removed, wet lint applied frequently, and the patient kept in bed for several days.

The operation of excision may subsequently have to be performed if the pain or sympathetic irritation do not subside, or if they result from suppuration in the stump. Poultices applied over the lids of the eye operated upon, and the treatment of the sympathetic irritation by atropia, should be tried previous to excision.

The latter operation has become necessary, in some cases, months after abscission, through secondary changes in the abscised eye, or through sympathetic affection of the other.

Abscission, instead of excision, has been found most effectual in cases of staphyloma following purulent ophthalmia.

Shrinking of the Eyeball, after insertion of a Seton.

A stout silk thread is drawn through the tunics of the eye, and through the vitreous chamber just in front of the insertion of the outer and inner recti muscles. The silk is withdrawn as soon as chemosis with impeded mobility of the eye shows itself. The eye is left to shrink. The artificial eye is inserted as soon as the conjunctiva has resumed its natural appearance.

This mode of reducing the size of an eyeball has been recommended, instead of excision, for very large staphylomatous eyes.

EXCISION (ENUCLEATION) OF THE EYEBALL.

The operation of excision is indicated—

(1.) If vision of one eye is lost, and if "sympathetic changes" appear in the fellow eye. If an eye is blind and painful in itself, from whatever cause vision may have been lost. If we suspect the eye to enclose some foreign substance which cannot otherwise be removed.

(2.) In cancer of the eyeball.

The object of excision is to remove the eyeball, and as little of the conjunctiva, muscles, and optic nerve, as possible.

Excision has this advantage over abscission, that it speedily and permanently removes the inconvenience caused by the eye. This in poor persons, where time is of consequence, may be important. Excision is a less difficult operation, and admits of early insertion of an artificial eye.

Excision may have to be performed on a previously abscised eye, if suppuration or sympathetic changes set in.

Difficulties during the operation may arise from the shape of the eye. The tunics in shrunken eyes are generally uneven and furrowed behind the ocular insertions of the recti muscles; and the surface of the sclerotic is not unfrequently adherent to the soft parts of the orbit, so that the palpebral aperture may have to be enlarged for the removal even of a considerably shrunken eye. In ophthalmitis the solid infiltration of the orbital tissue, which surrounds the sclerotic, renders excision with scissors difficult; and sometimes it has been found easier to remove the eye with the scalpel.

Eyes with ciliary or equatorial staphyloma are often staphylomatous also round the optic nerve. If the latter staphyloma be wounded before dividing the optic nerve, the fluid contents of the vitreous chamber escape, rendering the complete removal of the collapsed eyeball more tedious.

A similar accident may occur if there is deep cupping of the optic disc. By dividing the nerve close to the sclerotic, the deepest part of the cup, reaching beyond the level of the outer surface of the sclerotic, is opened.

Ulcers of the cornea, or very thin staphylomata, may become ruptured during the operation.

In cases of tumours, especially of cancer, we should carefully separate *all* the muscles *before* dividing the optic nerve. The eyeball should be rotated in various directions, to expose the surface of the sclerotic and any tumour, that may be found attached to it. The optic nerve is then divided at some distance, say a quarter of an inch, from the eye, so as not to leave any of the cancerous tumour. The cavity of the orbit should at once be examined, and portions of tumour, that may be found behind the eyeball, should be removed.

The Operation.

Instruments required :—A strong wire speculum, a forceps, a strabismus hook, and a blunt-pointed pair of scissors, with curved blades.

The operation may be performed without chloroform in from one to three minutes. Chloroform should be given if the patient desires it, or if the operation is likely to be prolonged by adhesions, or by alteration of shape of the eye.

The patient, lying on a couch, has the eyelids kept open with the wire speculum. With scissors an incision is carried through the conjunctiva, close to and all round the margin of the cornea. The conjunctiva and subconjunctival tissue are then separated from the sclerotic up to the insertion of the tendons of the recti muscles, and these are divided close to their insertion. The insertion of the inner rectus muscle is divided last, and in such a manner that a small portion of the tendon is left attached to the eyeball, to be used for easier rotation and control of the eye, while dividing the optic nerve, oblique muscles, &c.

After having divided all adhesions between the soft parts of the orbit and the eyeball except the optic nerve, and perhaps the oblique muscles,

we gently press the speculum, together with the margin of the lids, backwards over the equator of the eyeball. This causes the latter suddenly to slip in front of the eyelids and speculum. We then firmly grasp the part of the tendon of the internal rectus muscle, which was left attached to the sclerotic, rotate the eye outwards, and introduce the curved scissors closed, and glide them along the sclerotic up to the optic nerve. By lateral movements of the closed scissors the exact position of the nerve is ascertained. Having felt it, we withdraw the scissors a little, open them, push them on again, and divide the nerve. This done, the eyeball readily escapes at once, provided the oblique muscles and all other adhesions have been previously separated. The somewhat copious bleeding, which follows, lasts for a few minutes. The blood may in part escape into the orbital tissue, and cause much swelling and protrusion of the eyelids if the eyeball has not been thoroughly freed from all adhesions previous to division of the optic nerve.

The lids being kept open by the speculum, cold water is made to run into the orbit until the bleeding ceases; or several pieces of lint, dipped into cold water, are placed into the orbit and secured by a bandage. The bleeding generally subsides in from ten to fifteen minutes. The speculum and lint are then removed, and a piece of wet lint tied over the closed lids.

Blood escapes into the subconjunctival tissue, and causes swelling and suffusion of the eyelids, if the speculum be removed while the blood flows freely.

The suffused blood disappears rapidly (within from twenty-four to forty-eight hours) if a poultice, made of the scraped root of black bryony, is repeatedly applied to the closed eyelids.

If, a quarter of an hour after the operation, the bleeding still continues profusely, as may occur after removal of large tumours of the eyeball, it should be arrested by "plugging" the orbit (the lids being kept open by the speculum) with small balls of wadding soaked with the tincture of the per-chloride of iron. The wadding is kept in place by a bandage.

The bandage and speculum are removed twenty-four hours later, while the wadding is left to be expelled spontaneously by suppuration. Suppuration appears in from three to five days after the operation.

An artificial eye is inserted as soon as the eyelids and conjunctiva have assumed their natural appearance.

Artificial Eyes.

An artificial eye can, as a rule, be inserted three weeks after excision of the eyeball, care being taken that the eye be not too large, the object being at this time merely to keep the lids in proper position. If the insertion has been delayed long, a small artificial eye should at first be

worn for a few days. This must be taken out if irritation or increased discharge follow, and be replaced by a still smaller one.

About a fortnight after insertion of the smaller eye, one which adapts itself well to the natural curvature of the lids can be inserted. The natural appearances of the lids and of the tear-puncta are thus preserved, and epiphora and displacement of the lids avoided.

The patient should be directed always to remove the artificial eye before going to bed, to sleep without it, and to wash it in tepid water, and to keep it in a secure place.

To take the artificial eye out.—Draw the lower lid downwards with the middle finger of the left hand, then with the right hand place the end of a small bodkin beneath the lower edge of the artificial eye. Raise the latter gently over the lower eyelid; it will then readily escape from between the lids. Care must be taken to prevent the brittle eye from falling on a hard substance.

To insert the artificial eye.—Place the left hand flat upon the forehead with the fingers downwards. With the two middle fingers raise the upper lid towards the eyebrow, and with the right hand put the upper edge of the artificial eye beneath the upper eyelid, which may then be allowed to drop upon the eye. Support the eye with the middle finger of the left hand; and with the right hand raise the lower lid over its edge.

After the artificial eye has been worn daily for one or two years its surface becomes rough, and the enamel destroyed. The eye should then be exchanged for a new one, especially if irritation or inflammation follow its prolonged use. Some persons can wear the eye eighteen months or two years, others only six months, before a change is required.

It occasionally happens, from patients taking much exercise, or being exposed to dry winds or heated air, that the mucus on the exposed surface of the artificial eye becomes dry, and irritates the conjunctiva of the eyelids.

This is avoided by placing the eye in water during the night. The dry mucus can be washed off with some sulphuric acid and water (one part of acid to five of water).

If these rules are followed out no "sinking" of the artificial eye occurs; and experience shows that the eyelids continue to assume a more natural appearance.

The artificial eye appears the more natural the less is removed of the soft parts of the orbit, and the smaller the orbit is and the more fat it contains.

If many of the soft parts within the orbit have been destroyed or removed, the eye must be large, and its margins made to rest upon the margin of the orbit in a nearly fixed position.

If the excision is followed by inflammation, or by much infiltration of

blood into the conjunctiva, a smaller eye has to be worn for a longer time. The final result, as regards appearance, is not unfavourable.

In cases, in which discharge continues for a long time, from a foreign body having become lodged in the orbital tissue, or from some other cause, a small artificial eye must be worn until the discharge has nearly ceased, when a larger one may be inserted.

The mobility of the artificial eye is most perfect if a "stump" has been left to support the eye. Any transparent cornea of a shrunken eye should, however, be removed on account of the irritation which it causes when in contact with the artificial eye.

Cases have occurred in which a band of thickened conjunctiva, extending from one canthus to the other, has gradually narrowed the palpebral aperture, and thus expelled the artificial eye. This in some measure may be obviated, and more space be made for the reception of the artificial eye, by dividing the band transversely. A vertical, or horizontal incision, as the case may be, should be made through the band in one or several places. The upper and lower ends of each incision are united by a suture, so as to cause the wound to assume a horizontal direction. The length of the band is thus increased, and contraction of the cicatrix prevented. In some cases granulations spring up after the eye has been worn for some time. These may become so large as to prevent the wearing of the artificial eye. In other cases sympathetic irritation is caused by the artificial eye.

Such accidents generally occur through the patient not having followed the instructions for the removal of the artificial eye, or through not having exchanged it for a new one in due time, or through too early insertion of too large an eye.

Entropion, ectropion, and other anomalies of the lids should be remedied previous to insertion of the artificial eye. Irritation, discharge, &c., with early corrosion of the eye, follow if this is neglected.

Poor persons, who are not able to procure a new artificial eye every year, or who are engaged in pursuits in which the eye is likely to be broken, had better not wear one, but cover the closed lids with a small green shade.

In several cases, in which no artificial eye could be worn, it has become necessary, on account of the purulent discharge and the irritation caused by malposition of the lids, to produce permanent adhesion between the margins of the lids. A small part of the palpebral aperture, including the tear-puncta, should in such cases be left untouched, to allow of escape of discharge.

CHAPTER VIII.

THE CRYSTALLINE LENS ("THE LENS").

ANATOMICAL AND GENERAL REMARKS.

The full-grown Crystalline Lens and its Capsule.

The capsule of the lens is a smooth, transparent, homogeneous, and very elastic substance, permeable to fluid, and intimately connected with the lens.

In the Museum of the Eye Infirmary, Moorfields, is a healthy lens (enclosed in its capsule) of which one half projects through the pupil. This lens, constricted by the pupil, resembles the figure .

The anterior half of the capsule is considerably thicker than the posterior. The former becomes suddenly thinner where it meets the suspensory ligament; and becomes still thinner over the margin of the lens. It is thinnest in the hyaloid fossa (at its posterior pole). The outer surface of the capsule has hitherto been found free from epithelial cells. A single layer of large polygonal transparent cells (similar in arrangement to the hexagonal cells of the choroid) is found on the inner surface (the one nearest the lens) of the anterior capsule. These cells touch each other; they are largest at and near the anterior pole; and become smaller and more numerous towards the margin of the capsule; at the margin they disappear. The centre of each cell is occupied by a large, round, well-defined nucleus, enclosing one or two nucleoli. Nucleated fibres of the lens are inserted into the inner surface of the posterior half of the capsule.

The "lens" itself is transparent to the naked eye, soft, gelatinous, or glutinous, and in consistency somewhat exceeding that of the white of an egg. It is not homogeneous, but consists of innumerable fibres, the thickness of some fibres being about $\frac{1}{5000}$ of an inch. Though soft, its fibres are firmly united with each other, and with the inner surface of the capsule.

This cohesion of the lens fibres in health becomes a great impediment in the treatment of those forms of cataract where only part of the lens has become opaque.

The lens fibres (tubes ?) are transparent, flat (the flattening being more marked towards their ends), somewhat hexagonal, very flexible, and filled with a substance (fluid ?) called globulin. The nearer the centre of the lens, the shorter and narrower are the fibres; those which are at equal distance from the centre of the lens have equal length. Each fibre is in contact with six others; its smooth anterior and posterior surfaces touching, the former the surface of a fibre nearer the capsule, the latter the surface of a fibre nearer the centre of the "lens." The sides of each fibre are doubly bevelled, and have numerous indentations, which interlock with those of adjoining fibres. Thus two fibres are connected with the sides of each fibre, and the union of the sides of the fibres is firmer than that of their anterior and posterior surfaces. All fibres pass from the anterior surface over the margin to the posterior surface of the lens. Each fibre has two extremities. The fibres may be pealed off in layers, similar to the coats of an onion; they run parallel with the curvature of the lens. A fibre, e. g., commencing at the anterior pole of the lens, next the capsule, bends round the margin, and passes on towards the posterior pole, but does not reach it; the next two fibres, the one on either side of the first, commence at some distance from the anterior pole, but having passed the margin of the lens, approach nearer the posterior pole in the same layer of lens fibres, and so on. The points of insertion of the lens fibres next the anterior capsule, when viewing the anterior surface of the lens (microscopically), are seen to form a line. Three such lines can be perceived radiating from the anterior and posterior poles; these are termed the primary lines. In the full-grown lens they extend through its thickness from pole to pole; at some distance from the centre they divide and subdivide into secondary, tertiary, &c., lines; none of these reach the margin of the lens. They give rise to the star-shaped figures often observed on the anterior and posterior surfaces of the lens. The lines on the anterior surface do not correspond in position to those on the posterior surface; but the former if continued would divide the angles of the latter into halves. The individual fibres, as they approach their point of insertion, lose their outlines, and with the adjoining ones merge into a homogeneous transparent substance. The lines of insertion of each layer of lens fibres of the anterior and posterior half of the lens are situated behind each other, and form what is termed a plane.

In the newborn the lens, viewed from its anterior or posterior surface, presents a tripartite figure, which is still to be recognized in the "nucleus" of the adult lens.

The lens increases in size by the deposition of new fibres upon the old

ones. The lines (planes) of the tripartite figure become longer, and subdivide.

The capsule of the lens, with its so-called epithelial cells, is looked upon as the matrix for the lens fibres, each "epithelial cell" growing out into a lens fibre. The deposition of new lens fibres is said to cease after the body has reached its full development.

The fibres of the lens as *age advances* assume a yellowish tint, which becomes more and more intense, sometimes quite amber-coloured. They become larger, flatter, and harder. This increase in density advances from the centre towards the surface, and makes itself already felt before puberty by changes in the range of accommodation. The harder central portion of the lens is termed the nucleus. The lens also becomes flatter, and, together with the iris, approaches the cornea; the quantity of light reflected from the surfaces of the lens increases, and its sectors become much more conspicuous. The lens of a person aged 70 is nearly as heavy again as that of a person aged 20. (See Presbyopia.)

The capsule loses its elasticity and becomes brittle, and often fissured. Globular, pedunculated, and other excrescences of varying size, and consisting of a substance which chemically and in transparency is similar to the texture of the capsule, are frequently observed on the surface.

The integrity of the capsule seems indispensable for the proper nutrition of the fibres of the lens.

Aqueous humour containing sugar, albumen, and salts, influences the nutrition (transparency) of the lens. How far the aqueous humour or the vitreous substance participates in the nutrition of the lens is not known.

The margin of the pupil, together with part of the iris, glides up and down upon the anterior surface of the capsule of the lens. The anterior pole of the lens projects a little beyond the plane of the pupil. The axis of the lens nearly coincides with the direction of the visual line; the posterior surface is more convex than the anterior; it is, except near and at its margin, firmly attached to the hyaloid fossa, which, together with the suspensory ligament, are supposed to keep the lens in situ.

The margin of the lens does not touch the ciliary processes, but projects into a canal (the canal of Petit) which is occupied by transparent fluid. The boundaries of this canal are the margin of the lens and the anterior and posterior portions of its suspensory ligament. The latter is a transparent membrane intimately attached to the margin of the retina, and to the cilary processes. It does not enter into the sinuosities of the latter, but passes evenly over them. A space (occupied by aqueous humour) exists between the iris and the nearest part of the suspensory ligament. Before reaching the margin of the lens the suspensory ligament separates into an anterior and a posterior portion. The former is attached to the anterior surface of the capsule at some distance from its margin, and is the stronger

of the two ; it assists in separating the posterior aqueous chamber from the canal of Petit and from the vitreous chamber. The posterior portion is attached to the posterior surface of the capsule, near its margin. Fibres, which are continuous with the suspensory ligament, may be perceived upon the outer surface of the anterior and posterior part of the capsule of the lens. They appear as delicate lines converging from near its margin towards the poles of the lens.

Examination.

The lens in young persons appears transparent, to the unaided eye. The portion occupying the area of the pupil presents a faint greyish blue, and slightly opalescent tint if the light of a lamp is concentrated upon it by means of a convex lens. This reflection is stronger in those who suffer from asthenopia. It is caused by some of the light, reflected from fibres of the lens, rendering the strongly-illuminated portion of the lens visible in front of the dark vitreous chamber.

The healthy lens, when examined with the ophthalmoscope, appears transparent. If, however, a peripheral portion of the iris be missing, and we obtain a view of the margin of the lens and of the suspensory ligament, we find, when looking through the suspensory ligament, that the latter is more transparent than the lens itself, the margin of which can readily be recognized.

Many details of the lens of the living eye can be examined microscopically by a combination of an ophthalmoscope with a microscope.

If we wish to see the crystalline lens of our own eye, we should look at the bright sky through a small opening (of about ·00393 in. in diameter) in a black metal plate, holding the opening at about ·51182 in. from the eye. Not only do we perceive the radiating figures due to the sectors of the lens near its poles, but also various kinds of globules, and of opaque and bright spots. To see these more fully the pupil should be dilated by atropia.

We all know that, the flame of a candle being held in front of the eye, three images of the flame are seen on the refracting surfaces ; one upon the cornea, one (an erect image) upon the anterior surface of the lens, and an inverted image upon the concave hyaloid fossa. The inverted image moves in a direction opposite to the erect one when displacing the flame. These images betray the situation of the light-refracting surfaces of the eye, and have been measured by means of an instrument termed *the ophthalmometer.* With this instrument the place and curvature of the middle of the anterior and posterior surfaces of the lens, and the changes of curvature which the lens undergoes during accommodation, have been ascertained. It has been found that the distance of the anterior from the posterior pole of the lens is greatest, i. e. that the lens has its greatest thickness (in young per-

sons about ·17382 in.) when the eye is accommodated for the nearest point of distinct vision. The distance from pole to pole amounts to about ·14839 in. when the eye is accommodated for the farthest point of distinct vision. The distance of the posterior pole of the lens from the apex of the cornea has been ascertained as being about ·28111 in.; that of the anterior pole about ·13271 in.

Development.

Nothing reliable is known regarding the state of the lens during the first month of fœtal life. Some believe that during that period it consists of two disc-shaped substances, their flat surfaces touching each other, their curved ones forming the anterior and posterior curvatures of the lens.

In the second month the lens (loosely enclosed in its capsule) has a somewhat globular shape with a pointed projection of its posterior pole; the latter almost touches the tunics of the eye, and is directed towards the fœtal fissure. This projection is still perceptible about the fourth month. Even about the ninth month the capsule but loosely encloses the lens.

At the end of the fifth month the central artery may be seen passing through the vitreous chamber. On reaching the capsule of the lens at its posterior pole, or a little inwards and downwards from it, the artery splits up into three, rarely into four or five branches, which form numerous anastomoses on the posterior capsule. It sends branches round the margin of the capsule upon the outer surface of the anterior portion. The anastomosing branches upon this part of the capsule are supposed to pierce the latter, and to give rise to the intra-capsular "epithelium." These branches anastomose with the vessels of the pupillary membrane. At the end of the fifth month this network of blood-vessels disappears from the capsule, generally sooner in one eye; and the vessels become "obliterated," the obliteration progressing from the lens towards the optic disc.

Congenital Anomalies.

Anomalies of Shape.

Indentations of the lower edge of the lens, and interruptions of the circular shape (as if segments of the lens were missing), are sometimes met with (especially in hypermetropic and in colobomatous eyes).

A raphé or a groove may be found extending along the margin of the lens, and is attributed to imperfect union of its anterior and posterior halves.

Several grooves (sulci) extending from the anterior to the posterior pole of the lens have been observed, and are ascribed to absence of some of the fibres of the lens.

The lower margin of the lens has been found tapering off into a pointed prolongation directed towards the fœtal fissure.

A depression is often met with at the anterior pole of the lens, through absence, or not meeting of some of the fibres of the lens. An opaque deposit in this depression gives rise to a form of congenital cataract.

An absence of the whole (aphakia) as well as of the anterior half of the lens, has been observed. Two lenses have been found in cyclopic eyes.

Anomalies (*a.*) of position, and (*b.*) of transparency.

(*a.*) Dislocation of the lens, generally in both eyes, though perhaps not to the same extent. Three varieties are described—Dislocation into the anterior chamber; dislocation laterally, so that part of the periphery of the lens comes to stand nearer the ciliary processes than the remainder; and oblique positions, the outer (temporal) margin of the lens pushing the iris next to it forwards, while the opposite margin recedes into the vitreous chamber.

(*b.*) Changes in the shape and arrangement of the elements of the transparent lens, causing irregularities in the refraction and reflection of the light, and opacities of the lens. (See Congenital Cataract.)

PRESBYOPIA (= *Pr.*)

Aged sight. Far-sightedness.

Vision. Persons who are presbyopic in a high degree are readily recognized by their holding type, when reading without spectacles, unusually far from the eyes. This they are compelled to do on account of alterations in the parts acted on by the adjusting power of the eyes. Presbyopics see better (i. e. objects appear less diffused) if their pupils are much contracted, as is the case in bright light.

Complaints as regards vision generally arise, as soon as small objects can no longer, or only with difficulty, be recognized.

If asthenopia accompanies the appearance of presbyopia we generally find that more or less hypermetropia also exists.

The acuteness of vision for distance also diminishes, though rarely to a degree to attract attention.

Type No. I., which young healthy eyes can read at 1′ (this being the farthest point of distinct vision for that sized type), can, by the same eyes, if the parts necessary for accommodation are healthy, also be read at 4″ (this being the nearest point of distinct vision). Now if with increase of years, say at the age of 45, the same eyes can still read type No. I. at 1 foot, but no longer at 4, but only at 8 or 10 in., it follows that age has not yet sensibly altered the acuteness of vision, but has impaired the function of the parts concerned in accommodation, since the nearest point of distinct vision has receded from the eyes.

Presbyopia is the result of a senile change of the crystalline lens. The latter becomes firmer as age advances, and loses the flexibility and elasticity which is necessary to enable it, by the aid of the ciliary muscle, to assume that degree of curvature which is required for distinct vision of near or small objects placed, e. g., at from 4 to 8 in. from the eyes.

The firmer the crystalline lens becomes the less can its curvature be increased by the action of the ciliary muscle, and the farther have objects to be held from the eyes to be seen distinctly.

A change of consistence of the crystalline lens occurs in every eye, whether it be normal (emmetropic), or myopic, or hypermetropic. Every eye, as age advances, becomes presbyopic.

Physiologists have agreed to consider a person presbyopic as soon as the nearest point of distinct vision lies at 8 in. or farther from the eye.

To find in presbyopia the exact situation of the nearest point of distinct vision we make use of spherical convex lenses, and ascertain, by experiment, which convex lens held close in front of the presbyopic eye brings the nearest point of distinct vision to about 8 in. This lens found, we wish to know for what point the eye was accommodated without the lens. To answer this question we must deduct from $\frac{1}{8}$ the power of the glass lens which was ascertained by experiment; e. g. suppose that with a convex lens of $\frac{1}{16}$, held close in front of the presbyopic eye, letters of No. I. can be read at 8 in. from the eye and not nearer, we know that the nearest point of distinct vision lies at 8 in. from the eye when looking through $\frac{1}{16}$. The question therefore is, at what distance does this point lie from the eye, or for what point is the eye accommodated without the lens. The question is solved by deducting $\frac{1}{16}$ from $\frac{1}{8}$ $(\frac{1}{8} - \frac{1}{16} = \frac{1}{16})$.

From the result obtained we infer that, by the greatest effort of accommodation, the eye can increase the convexity of its crystalline lens to such an extent as to bring the nearest point of distinct vision to 16 inches. (See range of Accommodation.)

By this calculation we have ascertained *the degree* of the presbyopia, i. e. the amount to which the power of accommodation falls short of accommodating the eye for distinct vision of a point situated at 8 in. from the eye. A presbyopia of $\frac{1}{20}$, $\frac{1}{15}$, $\frac{1}{10}$, &c. ($Pr = \frac{1}{20}, \frac{1}{15}, \frac{1}{10}$, &c.), signifies that a convex lens of $\frac{1}{20}$, $\frac{1}{15}$, $\frac{1}{10}$, &c., is required to bring the nearest point of distinct vision to 8 inches from the eye.

Treatment.

The impairment of vision, when the result of presbyopia alone, is relieved by spectacles with convex lenses.

Previous to finding the spectacles for reading and other near work, we ascertain:

(1.) Whether the acuteness of vision is such as may be expected at the age of the patient.

(2.) What is the state of the refraction and of the accommodation of the eye.

If we find that the patient cannot read No. I. at 1 ft, or not nearer than 8 in. or 10 in., or No. II. only at 24 in. or 20 in. and not nearer, but that he distinguishes the letters of No. XX. at from 16 ft to 20 ft, and that with spherical lenses he can distinguish distant letters less acutely, we have to do with pure presbyopia.

Experience has shown that presbyopia increases to a certain extent every year; and that, the eyes being otherwise healthy, the age of the patient can in a great measure be taken as a guide which lenses to try first to find the spectacles required.

Persons aged from 40 to 50 we try with lenses of from $\frac{1}{80}$ to $\frac{1}{40}$. The patient, if the lenses are properly selected, should be able to read holding the book, &c., at 14 in. from the eyes, and he should see distinctly with them at from 10 in. to 60 in.

Persons aged from 50 to 60 we try with lenses of from $\frac{1}{40}$ to $\frac{1}{20}$. These lenses, if properly selected, should admit of easy reading when holding the book at 14 in. from the eyes, and the range of distinct vision with them should extend from 12 in. to about 30 in. from the eyes.

Those aged from 60 to 70 we try with lenses of from $\frac{1}{20}$ to $\frac{1}{10}$. The spectacles are the proper ones if the patient can read with ease holding the book at about 12 in., and if he has distinct vision with them at from 10 in. to 16 in. or 18 in. from the eyes.

At the age of from 70 to 80 we try lenses of $\frac{1}{10}$ to $\frac{1}{7}$. With these the patient should be able to read, holding the book at the focal distance of the lenses selected, i. e. at from 7 in. to 10 in.

The patient must abstain from near work, and from the use of spectacles, if morbid changes, accompanied by inflammation or increase of tension, are found together with the presbyopia. In all other cases in which the acuteness of vision is less than might be expected at the time of life of the patient, we may try spectacles with convex lenses.

If the refraction of the eye is abnormal.

Suppose we find that our patient, aged 40, cannot read No. XX. at 20 ft, but only No. XXX. or No. XL., but that, a convex lens, e. g. $\frac{1}{30}$, being held before each eye, he is able to spell No. XX. at 20 ft, we thence infer that he is *hypermetropic.* We now, before selecting the spectacles for reading, ascertain the degree of the hypermetropia. If we find the hypermetropia to be equal to $\frac{1}{40}$, i. e. that a convex lens of 40-inch focus is the one which, being held before each eye, improves vision most for distance,

we then proceed to ascertain the degree of presbyopia. We select the spectacles according to the age of the patient as stated above, but to the lenses thus found we subsequently add the number with which vision for distance is most improved; and lenses of this kind should be used for reading. Suppose that besides a presbyopia of $\frac{1}{30}$ we find a hypermetropia of $\frac{1}{40}$, we do not give for reading spectacles of $\frac{1}{30}$, but spectacles of $(\frac{1}{40} + \frac{1}{30} = \text{about } \frac{1}{17})$ about $\frac{1}{17}$, i. e. with convex lenses of 17 in. focal distance.

If the patient is slightly *myopic*, and spectacles with convex lenses should become necessary on account of the presbyopia, we first ascertain the degree of the myopia; we then deduct that degree from the lens which we would give for reading if the patient were not myopic; e. g. if there is myopia of $\frac{1}{50}$ and presbyopia of $\frac{1}{30}$, instead of giving spectacles for reading with lenses of $\frac{1}{30}$, we give them with lenses of $\frac{1}{30} - \frac{1}{50} = \frac{1}{75}$.

"Stronger spectacles" are required if, considering the time of life, the accommodation is abnormally diminished, whatever may be the cause of the diminution, glaucomatous changes excepted. We may find commencing cataract, or paresis of accommodation, or rapid senile diminution of accommodation. If the refraction is normal, we try in such cases spectacles which allow of easy and distinct vision at the distance at which the patient wishes to see, e. g. to see distinctly at 10 in. we try spectacles with lenses of $\frac{1}{10}$; at 20 in. lenses of $\frac{1}{20}$, &c.

If there is *hypermetropia* we proceed as above by adding the lens which indicates the degree of the hypermetropia to the one we wish to give for reading, e. g. if we find the hypermetropia $= \frac{1}{40}$, and we wish to give spectacles with lenses of $\frac{1}{10}$ we give $(\frac{1}{40} + \frac{1}{10})$ $\frac{1}{8}$ instead.

If we find myopia we deduct its degree from the lens we wish the patient to use, e. g. if we have a myopia of $\frac{1}{40}$, and wish to give lenses of $\frac{1}{15}$, we instead of $\frac{1}{15}$ give $(\frac{1}{15} - \frac{1}{40})$ $\frac{1}{24}$.

Presbyopic persons with hypermetropia sometimes make use of spectacles with lenses with two foci, using the upper third of the lens for looking at distant objects, the lower two-thirds with shorter focal distance for near work.

The axis of the lenses for reading should coincide as nearly as possible with the visual lines, i. e. the eyes should look through the middles of the lenses. These must be so inclined that, when looking at distance, the eyes look over them.

At first the spectacles should only be used in the evening, while during daylight near work is performed without them. Gradually they are used also during the day, while a "stronger pair" may be required for night-work.

CATARACT.

GENERAL REMARKS.

Cataract is the term applied to a peculiar change in the lens, the chief symptom of which is loss of transparency, generally accompanied by alteration in the consistence and cohesion of the fibres of the lens, with subsequent absorption of the more fluid parts. These changes may be the result of fissures in the capsule (? a senile change) bringing the aqueous humour into direct contact with the lens fibres; or they may be caused by altered nutrition, as during inflammation of adjoining tunics, in diabetes, or after injury.

The various names given to different forms of cataract are derived either from the consistence or from the colour of the cataract; or from the age at which it occurs; or from the state of the eye, &c., &c.

The loss of transparency appears more rapidly in some portions of the lens, and generally sooner at the surface ("in the cortical substance") than in the nucleus.

The "fibres" of the lens in the common forms of cataract, when examined minutely, and at different stages, appear at first finely dotted, then (gradually losing their outline) indistinct, and surrounded by irregular-shaped, nearly transparent particles termed myeline, and by large and small globules resembling drops of oil, and by minute dark or clear granules.

The portion of the cataract which is in contact with and near the capsule is termed the *cortical substance*, or surface matter, to distinguish it from the deeper parts of the cataract, termed the *nucleus*. The latter, when removed from the capsule in senile cataract, is hard, generally translucent, and has somewhat the appearance of a bi-convex lens, while the cortical substance is soft and opaque.

Simultaneously with the changes of the lens fibres, we find many of the intra-capsular ("epithelial") cells without cell walls, and their nuclei more or less opaque. Some cells appear large and granular, resembling pus cells. The cells often disappear altogether, and the altered lens fibres are found in immediate contact with the capsule.

The loss of transparency (colour) of the lens is accompanied by alterations in the cohesion and consistence of its fibres. These lose the gelatinous consistence, and become more or less fluid. The fluid is supposed to escape gradually through the capsule into the aqueous chambers, and to become absorbed. The size of the cataract, which at one time may have considerably exceeded that of a healthy lens (bulging the iris forwards),

becomes less. The cataract may shrink to such an extent as to give rise to tremulous iris through the latter losing its support. The semitransparent nucleus, after spontaneous absorption of the opaque matter, may become visible again.

The nucleus of cataract in old persons is generally large, flat, and slightly convex, while in middle-aged persons it is smaller and more convex. Two bi-convex nuclei have been found in the same cataract.

The yellowish transparent, the brownish-grey, and the amber-coloured nuclei are the most frequent.

The elimination of what is termed myeline is less marked among the fibres of the nucleus.

Examination for Cataract.

The presence of cataract and its kind are best recognized by artificial light ("by focal lateral illumination").

The patient (the pupil being dilated with atropia) is placed in a dark room, and the light of a lamp is concentrated in succession upon different parts of the lens, by means of a bi-convex lens of about 2-inch focus.

The faintest alterations in transparency can thus be recognized. The details of the opacities may be examined with a second lens. Opacities which, thus viewed, appear in their natural colour, e. g. grey and opaque, appear, when looked at with the ophthalmoscope, as black spots, streaks, &c.

The presence of cataract having been ascertained, we determine as far as possible its consistence (see Consistence of Cataract), and then the condition of the retina, choroid, &c.

Opacities in the vitreous chamber, blood-spots in the retina, anomalies in the colour, curvature, &c., of the optic disc, can in many cases be recognized through less opaque portions of the cataract. After this we test the retina for its *sensibility for light.* Complications with amblyopia are thus recognized. Experience must teach us the amount of light thrown through the cataract that can still be perceived by the healthy retina. Attention should particularly be paid to the sensibility of the most depending parts of the retina, these being more frequently impaired, especially in traumatic cataract, and in cataract with myopia.

As regards complications arising from changes external to the eyeball, it may be remarked that extraction of cataract has been successfully performed in patients with granulations, tinea, trichiasis, everted tear-puncta, or purulent discharge from the lachrymal sac.

Numerous enlarged vessels emerging from the sclerotic near the cornea always indicate some anomaly in the circulation of the choroid, and frequently glaucomatous changes. If cataract be coupled with increased

tension iridectomy should be performed some weeks previous to the removal of the cataract.

Opacities in the cornea may require iridectomy to carry the pupil behind transparent cornea.

A shallow anterior chamber is observed when a large, "swollen," cataract displaces the iris forwards.

A deep anterior chamber may be a sign of a small shrunken lens, or of inflammatory changes of the cornea, such as occur in inherited syphilis.

A tremulous iris is not necessarily a sign of fluid in the vitreous chamber. Fluidity of the vitreous within the area of the retina, that within the area of the ciliary processes being normal, or the floating of a small hard nucleus in a loose lens capsule, may cause it. Shrinking of the cataract, together with increase of aqueous humour, may cause the tremulousness. In cases with tremulous iris scoop extraction with iridectomy (under chloroform) should be performed.

The *pupil* in every case should be dilated by atropia previous to performing any operation. An iridectomy is performed if the pupil does not become dilated by atropia, or if the pupil is irregular from synechiæ.

We must not neglect to ascertain the *shape of the eyeball.* Small or hypermetropic eyes frequently present glaucomatous complications. Myopic and large eyes often contain fluid in the vitreous chamber, and present retinal and choroidal complications. Great protrusion of one eye, or of both, may exist without any morbid changes of the tunics.

Causes.

(1.) Injuries (perforation of the tunics, or mere concussion of the eyeball) may at any age produce cataract of the injured eye.

(2.) Altered nutrition occurring in the course of morbid changes of surrounding tunics, especially after choroido-iritis (so called Secondary Cataract). The opacities caused by iritis are generally circumscribed (grey-white dots or streaks), and situated immediately beneath the anterior capsule. Serous effusion behind the iris and glaucoma give rise to diffused opacity, and to increased density of the lens.

Posterior polar cataract frequently occurs in myopic persons. Anterior polar cataract in children who have had purulent ophthalmia with corneitis.

A peculiar form of cataract (the green and black one) arises from deposit among the lens fibres of hæmatin and other colouring matters.

Cataract (the consistence of which varies according to age) is often observed in both eyes of persons who suffer from diabetes mellitus, or who have taken secale cornutum for a prolonged period, and not unfrequently in females during suckling. In the latter case it generally remains confined to one eye.

Congenital cataract most frequently occurs in children suffering from inherited syphilis.

Cataract in old persons (senile cataract) is attributed to impaired nutrition of the fibres of the lens, and to anomalies in the permeability of its capsule.

Consistence of Cataract.

The treatment of cataract would vary but little if its consistence were the same in all cases. If every cataract were fluid, we should uniformly remove it by suction. If all cataracts were hard, we should have to deal with them by the more hazardous operation of extraction.

The consistence of the healthy lens varies according to age. Up to the age of thirty-five it is glutinous. About that time a difference becomes apparent between the central and the more superficial portions. The former become more yellowish, and are termed the nucleus. Large hard nuclei have, however, been extracted from the eyes of persons aged from twenty to thirty (after iritis). In rare cases the change from glutinous consistence to hardness extends throughout the lens. The hard nucleus is rarely opaque, but generally yellowish and translucent. A complete absence of nucleus is in old persons extremely rare. The nucleus is generally surrounded by opaque lens matter. The latter varies in consistence, and is not unfrequently fluid, or so soft that the nucleus sinks in it. If the nucleus floats it gives rise to tremulous iris, and during movements of the eye rolls about in the opaque fluid. The sinking of the nucleus is always a sign of softening of the surrounding lens matter. It can frequently be recognized by examination with the ophthalmoscope, the pupil being well dilated, when the reflection peculiar to the nucleus is perceived, not in the centre, but near to, or at the lower margin of, the cataract. The sinking of the nucleus is thus far favourable, that, together with the soft matter, it can be removed through a smaller incision.

We distinguish four varieties of consistence, and as many forms of cataract:—*the fluid, the soft, the glutinous, and the hard cataract.*

The fluid cataract is white or grey; or yellowish-white and uniformly opaque, and, as a rule, without grey and opaque streaks or dots. An abundance of particles of lime settling at the lower half of the capsule may, however, give rise to a difference of colour, this part appearing more intensely white and opaque. The movements of the eye cause the chalky fluid to mix with the rest, and for a time to impart to the cataract a uniform white colour.

The change into fluid commences at the surface nearest the capsule, and rarely extends over the entire lens. Often a brownish hard, small, well-defined nucleus floats in the fluid.

A rare form of fluid cataract is a change of the lens into a yellowish,

nearly transparent oily liquid. All fluid may become absorbed, and merely particles of lime remain attached to the thickened capsule. The fluid readily escapes if the capsule is punctured.

Fluid cataract is frequently congenital, and has been observed at all ages.

The soft cataract.—We must distinguish between the kind of cataract which, when incising the capsule, in great part escapes spontaneously (it is generally termed *soft cataract*), and the kind which is described as *gelatinous cataract*. The softening, as a rule, commences at or near the capsule. In rare instances it occurs first in the centre, which then appears bluish-white and opaque, shading off into more translucent opacities dispersed through the superficial layers of the lens.

Examination with the ophthalmoscope shows that in soft cataract the marginal parts appear more opaque than the centre if the nucleus is transparent; while the opacity is densest in the middle, if the nucleus is also opaque.

The cortical substance may be considered soft:—

(1.) If the opacity reaches up to the capsule ("to the margin of the pupil"). (2.) If the cataract has a white and opaque colour, its surface being dotted over with ill-defined (diffuse), irregular-shaped opacities; or with broad, ill-defined, and opaque streaks. (3.) If in the eye with cataract (supposing only one eye to be affected) the iris is pushed forwards, and the pupil slightly dilated and not very moveable.

Cataract in persons below thirty-five, presenting the above signs, is as a rule soft throughout. The older the patient the more must we expect to find a hard nucleus of varying size, surrounded by soft cortical substance.

The gelatinous or glutinous cataract has the consistence of the crystalline lens in health. No lens matter or only a little escapes after incising the capsule. It is difficult to recognize this kind of consistence if no opaque streaks are visible. The narrower these streaks are the more glutinous is the cataract.

It is glutinous, (1.) If the layers of the lens nearest the capsule are transparent or semiopaque, so that we can to a certain depth look into the cataract. (2.) If narrow and opaque streaks alternate with transparent lens substance.

The cataract following choroido-iritis in young persons is often glutinous; so also is the one described as lamellar cataract.

The hard or senile cataract derives its name from the hard consistence of the "nucleus," while the portions of lens nearest the capsule are, as a rule, more or less soft. The cataract frequently commences in the portion of the lens near the nucleus, while the latter remains brownish yellow, and semitransparent. The nucleus often becomes smaller, while the superficial (fluid or soft) and opaque lens matter becomes absorbed.

The term lamellar cataract has lately been introduced to designate a lens in which opaque layers of lens fibres alternate with transparent ones, e. g. the nucleus and the lens fibres immediately beneath the capsule may be transparent, while the intermediate parts of the lens are opaque or semiopaque. The opacity in this case is more intense near the margin of the lens. On examination with the ophthalmoscope we observe a reddish reflection from behind the cataract, when looking through its middle (the light returning through the transparent centre of the lens), which would not be the case if that part of the lens were opaque.

The appearance of diffused opaque streaks and dots immediately beneath the capsule indicate an increase of the cataract. The opaque layer often shrinks, causing the lens to become smaller. Other parts in their turn become opaque, so that at the age of thirty we may find the lens opaque throughout, while at the age of twenty-five it had the appearance of lamellar cataract. Another form of lamellar cataract is the one in which the anterior or the posterior half, or lateral portions of the lens, appear opaque and shrink, while the rest remains transparent. Lamellar cataract, when stationary, should be removed if the patient can only read large type. An artificial pupil should be made if, the pupil being dilated by atropia, ordinary type can easily be read. At the same time the patient must be told of the probable "increase" of the cataract.

The striated or streaked cataract.—Grey or white and opaque striæ, or streaks, appear first at the margin of the lens beneath its capsule. Here they are broadest, and extend over both surfaces of the lens, and frequently first over the posterior. In the latter case we find in a more advanced stage an opacity with radiating striæ, which, seen through the transparent bulk of the lens, appears concave and deep-seated. Sooner or later the striæ extend over both surfaces of the lens. The opacity may extend over the entire lens surface which lies next the hyaloid fossa, before any striæ appear on the anterior surface. Narrow grey and opaque or moderately broad but white and opaque striæ, are made up of opaque lens fibres of nearly normal consistence and cohesion, surrounded by healthy lens fibres. Striæ of similar size, but of a greyish opalescent colour, are softer and less coherent. If the striæ are broad, and the intervening lens substance is opalescent, with the iris pushed forwards and but slowly moving over it, we suppose the cataract soft throughout.

The "black cataract."—This rare form (the entire lens having a black or deep brown colour) has been found in eyes in which hæmorrhage has occurred in the vitreous chamber. Each lens fibre, when the cataract is examined minutely, appears transparent, but has a yellowish brown tint. The brown substance chemically resembles the colouring matter of blood.

Different from this form is the senile cataract with a reddish brown, or amber-coloured, or black nucleus, which occurs frequently.

The "green" cataract has been observed between the ages of forty and eighty in persons with strongly-pigmented irides. The lens, though nearly transparent, has a dark pea-green colour while within the eye, and a light yellowish-brown one when removed from it. The optic disc viewed through the lens appears hazy. The removal of this kind of lens is accompanied by improvement of vision. The absence of glaucomatous symptoms distinguishes this kind from the greenish lens of many glaucomatous eyes.

The chalky cataract has a characteristic dead-white, or yellowish-white and opaque colour.

The following are the three usual forms :—

(1.) A flat, irregularly-shrunken, somewhat disc-shaped, stony, hard cataract. (2.) A cataract consisting of a shell of chalk, enclosing opaque lens matter, blood-vessels, and cholesterine crystals. In rare cases the nucleus becomes changed into chalk. (3.) A lens changed into a chalky fluid, the heavier particles gravitating towards the most depending portion of the capsule.

Chalk in the form of minute white granules, or in groups of granules, or spiculæ, is found deposited on the surface of many transparent or opaque lenses. The lens capsule of the fluid variety is much thickened ; in the other varieties it is extremely thin. Minute and chemical examination of the cataract shows that it consists of carbonate and phosphate of lime, of cholesterine crystals, and of fat.

This kind of cataract is, as a rule, complicated with atrophic changes of the choroid, retina, &c. It has, in rare cases, been observed with a healthy retina, but with fluid in the vitreous chamber.

Spicules or shells of true bone with blood-vessels have, though rarely, been found within the capsule of the lens.

Cataract in diabetic persons is soft in young, and combined with a hard nucleus in old, diabetics. Choroidal or retinal complications are comparatively rare, while paretic or paralytic affections of the ciliary muscle are frequent.

The cataract generally has an opalescent surface, and is swollen, pushing the iris forwards.

In young persons it may be removed by suction ; provided it be, or have been, rendered quite soft.

Persons in the last stage of diabetes, who have had both eyes operated on simultaneously, have recovered good vision.

Cataract without complication, i. e. without morbid changes in other tunics is termed *primary ;* such may be the traumatic, the idiopathic, and the congenital cataract. *Secondary cataract* exists if morbid changes of the "vitreous," "choroid," &c., can be traced as the cause.

Vision.

Most of the complaints of persons suffering from cataract can be traced to the cataract interfering with the course of the rays of light through the crystalline lens; some to changes in the refraction and accommodation; others to amblyopia or amaurosis.

Black spots floating before the eye—dimness, or a mist which is not removed by spectacles—intolerance of light, obliging the patient to shade the eyes or to turn the back to the light, to be able to see small objects better,—are complaints often heard from persons suffering from incipient cataract. Numerous small ill-defined opacities cause much dazzling or diffusion of light, which is relieved by the use of spectacles with tinted glasses. A dark disc-shaped figure, with its centre somewhat clearer, and surrounded by a more transparent portion, has been described by some patients suffering from lamellar cataract. In such vision has been improved by the use of atropia.

In senile cataract with semi-transparent nucleus vision may improve gradually through spontaneous absorption of the opaque superficial "lens matter." It may improve suddenly through spontaneous displacement of the cataract from behind the area of the pupil.

Flashes of light of various colours, fiery circles, "falling stars," if observed in daylight, may be caused by the light, on entering the eye, impinging upon peculiarly-placed particles of cataract. Morbid changes in the nervous apparatus of the eye, especially if these symptoms are observed in the dark, are, however, the usual cause. They frequently occur in myopic eyes, and are then of less consequence.

Careful examination of the sensibility of the retina for light and ophthalmoscopic examination must decide how far these symptoms should influence our treatment. Pain in the ciliary region and over the "eyebrows," or a sensation of "grit" in the eye, are frequently complained of by hypermetropics with commencing cataract.

Vision after removal of cataract.

Spectacles are required to give the patient the best possible degree of vision, whether one eye has been operated upon or both.

Careful research has shown that after the complete removal of cataract the accommodation of the eye is wanting. The cornea is the only part which refracts the light; vision is the more perfect the nearer the retina lies to the focal distance of the cornea. Hence the power to read without spectacles, which some highly myopic persons obtain, after successful operation for cataract.

In the normal-shaped eye, deprived of its crystalline lens, and with a

cornea which has a focal distance of about $\frac{1}{1\frac{1}{16}}$ inch, the images of objects are formed behind the retina, and the farther behind the nearer to the eye the objects are held. If such eyes are able to distinguish objects, it is because the pupils are small (the smaller the greater the acuteness of vision); and because objects may be very indistinct, and yet, their forms being known to the patient, can be recognized. In such cases we must distinguish between recognition and acute vision of objects.

The rays of light, when parallel or nearly so, are refracted by the cornea and passing through the pupil, would be brought to a focus at the focal distance of the cornea but for the retina, &c., which intercepts their course. A diffused image of the object is formed on the retina. Hence it follows that if spectacles are used, objects can be seen with them with greatest distinctness only at one distance, and thence the necessity arises for several pairs of spectacles, if objects placed at different distances are to be seen distinctly.

The acuteness of vision in old persons is naturally diminished; it is often only equal to $\frac{1}{2}$ or $\frac{1}{3}$. This must be borne in mind when we select the spectacles.

If the tension of the eye is normal, the eye free from irritation, and the optic nerve and retina healthy, considering the age of the patient, we may give those spectacles which enable the patient to read holding the book at from 6″ to 8″. The focal distances of the convex spherical lenses which are generally inserted into the "reading spectacles" vary between $1\frac{1}{2}$ in. and 3 in. Lenses of 2 in. or $2\frac{1}{2}$ in., placed at $\frac{1}{4}$ in. from the eye, are most frequently required. Myopic persons often require much weaker lenses, sometimes $\frac{1}{6}$ or $\frac{1}{8}$.

The focal distances of the lenses required for distance varies between 3 in. and 5 in. Those of 4 in. (lenses of $\frac{1}{4}$) are usually given. Highly myopic persons sometimes see best without spectacles.

No spectacles should be allowed as long as the eyes are irritable, or their tension is increased, and they should at once be discontinued if these symptoms appear. Sometimes it happens that, six months or later after the operation, the acuteness of vision rapidly diminishes, so as to alarm the patient. If this is due to atrophy of the retina and optic nerve, or to glaucomatous changes, or to displacement of the retina, reading and other near work must be entirely prohibited. Often, however, we find as cause capsular obstructions or an unusually contracted pupil. Much benefit is derived from the habitual use of atropia. If the improvement of vision is sufficient, no operation for the removal of the capsular obstruction need be recommended.

If both eyes have been operated upon successfully, care should be taken to have the lenses of the spectacles placed at a proper distance from each other, so that no diplopia shall arise. (*See* Spectacles.)

The patient must be shown which spectacles to use for reading, and which for distance, and how to use them. The spectacles for distance by removing them farther from the eyes may often be used for reading large type. The patient may thus, in some measure, use the same pair of spectacles for distance and for reading.

Many patients are much distressed by the peculiar appearance of objects when viewed through spectacles for the first time. The steps, floor, &c., seem to be raised, and patients, when walking, try to adapt their movements accordingly. The cause of this lies in the fact that convex lenses alter the sizes and not the forms of the images formed in the retina, and thus lead the patient to believe the distances of objects to be less than they really are. We may assure the patient that, after having worn spectacles for some time, this will cease.

Spectacles for near work, reading, &c., should at first only be used in daylight, and for a short time. It is necessary to show the patient, when using the reading spectacles, at what distance to hold the book. It has occurred, from neglecting to do so, that patients, with eyes successfully operated upon, fancied the spectacles of no use, and the operation not to have succeeded.

If the curvature of the cornea has become altered through prolapse of the iris, or through inflammation of the cornea, we should try whether a more or less oblique position of the lens improves vision. If the desired degree of acuteness of vision is not obtained by this, and all other parts be healthy, cylindrical lenses may be of use.

Congenital astigmatism of the cornea, the lens having been removed, becomes more perceptible, and in some cases a considerably higher degree of acuteness of vision is obtained by prescribing spherico-cylindrical instead of spherical lenses.

If portions of the cornea are opaque, much benefit may be derived for reading by blackening the part of the lens which comes to stand opposite the opaque portion. The diffusion of light caused by the opacity is thus removed.

Treatment of Cataract.

General Remarks.

We inquire into the state of the general health of our patient, and treat medically any morbid change we may discover. Syphilis, affections of the kidneys, atheromatous changes in the arteries, &c., very much influence the final success of operations for cataract.

Thin, quiet persons with soft skin are the most favourable for extraction. Suppuration is frequently observed to follow in those with very white hair and rigid arteries ("with a hard large pulse").

Persons suffering from syphilis, gout, delirium tremens, asthma (emphysema), bodily deformities, have been successfully operated upon by extraction. Extraction with iridectomy (with the smallest possible incision) should be adopted in persons with cough, or with infirmities which prevent their remaining in bed for a few hours in succession.

In different quarters a local medical treatment has been recommended for the dispersion or for the arrest of the cataract. As far as I could learn, the remedies used for the purpose have contained Iodide of Potassium. The following is a copy of a prescription used by some continental oculists for dispersion of cataract :—

℞ Potassii Iodidi ʒvi. Tincturæ Conii et Mixturæ Oleosæ Balsamicæ aā ℥iii. From 12 to 15 drops to be rubbed over the eyebrows four times daily.

I have accurate notes of two patients, one a lawyer, who used the remedy for the last three years, and follows his occupation, which he could not do when I saw him for the first time ; and the other a lady who is much engaged in reading, near work, &c. In both cases the opacities have become whiter and smaller.

The age of the cataract.—Cataracts from thirty to sixty years old have been removed with good result. Vision has improved much after removal.

The age of the patient.—Persons aged ninety and ninety-four have been operated upon successfully by extraction on both eyes simultaneously. The habits of aged people are hardly disturbed by the operation of extraction with iridectomy and with a small corneal incision.

The season for extraction of cataract.—Cold or rainy weather is less favourable, since it prevents patients from taking out-door exercise after the operation. Hot weather (especially hot nights) prevents many patients from sleeping, and suppuration seems to appear more readily. Spring and autumn are the most favourable times ; though otherwise healthy persons may with perfect safety be operated on at any time of the year.

Removal of Cataract from one eye only, the fellow eye possessing useful vision.

The advantages of removing the cataract are that the field of vision becomes larger, the judgment of distances and shapes of objects more perfect, and the patient can more readily guard against accidents. Diplopia rarely follows, or soon disappears. Strabismus does not necessarily occur, and may as easily do so if the cataract is not removed.

The cataract, age and circumstances permitting, should be removed by absorption, or by a small corneal section with iridectomy. Vision of the

eye operated upon should occasionally be practised separately with an appropriate convex lens.

Removal of cataract from an eye which has no perception of light has often been performed with success. (1.) For reasons of personal appearance, e. g. if there is chalky cataract. (2.) For sympathetic irritation of the fellow eye caused by, or attributable to, a dislocated chalky or other cataract. (3.) In blind eyes, the tension of which is too great, and not the result of intraocular tumour.

Both eyes have frequently been operated upon simultaneously by extraction with good result. Cases however have occurred in which both eyes have been lost. It is a safer plan to operate on the second eye a week after the first. In selecting the mode of operating we must be guided by the accidents, &c., which may have happened during the first operation.

OPERATIONS FOR THE REMOVAL OF CATARACT.

REMOVAL OF CATARACT BY "EXTRACTION."

The object of the operation is to remove—"extract"—the cataract through a large incision in the cornea, or in the sclerotic close to, and in front of, the insertion of the iris.

Many surgeons combine an iridectomy with every operation for hard cataract, others confine iridectomy (1.) To eyes with posterior synechiæ; (2.) To cases in which suppuration of the flap of the cornea is likely to happen ; (3.) To traumatic cataract in old persons ; (4.) To cataract with a very large hard nucleus ; (5.) To cataract in which the superficial part of the lens is of normal consistence ; and (6.) To dislocated lens.

Operation.

The patient is put to bed, lying on the back, and facing the light, with the head slightly raised, and the hands watched by an assistant.

The surgeon sits or stands behind, and, e. g. when operating upon the right eye, places the tip of the forefinger of the left hand upon the middle of the outer edge of the margin of the upper lid, and gently raises the lid above the margin of the cornea by causing it to glide along the curvature of the eyeball. Slight pressure is then made upon the eyeball with the tip of the forefinger, and with that of the middle finger upon the side of the eyeball near the inner margin of the cornea. Thus much control is obtained over the movements of the eye. An assistant draws down the

lower lid, and presses it against the malar bone without touching or dragging the eyeball.

Some surgeons keep the eyelids open with a light stop-speculum, and fix the eye with forceps. If the stop-speculum is used, it should be carefully removed after the incision is completed.

Others raise the upper lid as just stated, while an assistant fixes the eye with the forceps at the insertion of the inferior rectus, draws it down, and at the same time depresses the lid. The forceps are removed shortly before completing the corneal incision.

Having secured the greatest possible control over the eyelids and eyeball, the cataract knife is taken into the right hand. The thumb is placed on one and the fore and middle fingers on the other side of the handle, near the spot where it joins the blade. The little finger of the same hand rests upon the patient's face. The point of the knife is thrust through the cornea at its junction with the sclerotic, and a little above the point where its horizontal meridian touches the sclerotic. The knife is steadily pushed across the anterior chamber, the blade remaining as much as possible parallel with the iris. The point of the knife is again thrust through the cornea about opposite the spot where it entered.

The cutting edge of the knife, while making the incision, is directed towards the upper margin of the cornea, and the incision is completed by a to-and-fro movement of the blade, without allowing the point to return into the aqueous chamber. The line of incision, if well made, should be parallel with the margin of the sclerotic. A crescentic flap should be formed which comprises nearly the upper half of the cornea. The size of the corneal flap depends upon the size of the hard nucleus, which we should ascertain as nearly as possible. The flap should always be sufficiently large to allow the nucleus of the cataract to escape with the greatest ease. The incision must be completed very slowly, and at a moment when there is not the least straining on the part of the patient, and no pressure whatever exercised upon the eyeball.

The incision being completed, the lids are released and gently closed.

After a minute's rest, we proceed to the laceration of the anterior capsule. An assistant draws down the lower lid while the operator carefully raises the upper lid. The patient is directed to look downward ("towards his hands"). The operator with the right hand introduces the pricker through the wound in the cornea (raising the latter as little as possible, and without touching the iris) to opposite the middle of the pupil. He then directs the point of the pricker towards the cataract and, without displacing the cataract or pressing hard upon it, pierces the capsule and makes several incisions into it, so as to lacerate an area which is about equal in size to a moderately dilated pupil. No resistance is felt when incising

the capsule unless it be thickened. In rare cases the thickening is so considerable that the pricker cannot pierce it, in which case a sharp hook must be used to withdraw as much of the capsule as will follow. Sometimes cataract and capsule can thus be removed together. (The removal of the capsule, or cataract and capsule, with the sharp hook, should always be attempted.) The capsule having been opened, we again "drop" the lid for a few seconds, and then proceed to the removal of the cataract.

Experience is required as regards the necessary amount of pressure upon the eyeball to cause the cataract to escape. To do this we place the flat part of the scoop upon the lower lid near its margin, while the patient looks downwards. We then press with the scoop gently upon the sclerotic, the tip of the forefinger of the left hand, which keeps the upper lid raised, being placed upon the eyeball. Careful alternating pressure is now made upon the eyeball in these two parts. This should cause the cataract slowly to advance into and through the pupil, and through the incision in the cornea. As soon as the greatest diameter of the cataract lies in the section we cease pressing. The margin of the lid, or a finger, or the scoop is used to remove the cataract from the section. After the nucleus has escaped and been removed, we close the lids gently, and allow the patient to rest a minute. By placing the tip of one finger upon the closed upper lid, and gently rubbing the lid against the cornea, we cause the soft parts of the cataract, accumulated behind the iris, to advance into the area of the pupil. We then raise the lid, and carefully remove the soft parts of cataract with the scoop. Some of the soft cataract may be left, if the iris shows much tendency to bulge; the pupil however must be afterwards kept well dilated by atropia. The lids of both eyes are then closed carefully with narrow strips of sticking plaster, and two pieces of lint, dipped in cold water, are tied lightly over the closed lids of each eye.

Accidents during the operation.

(1.) The aqueous humour may escape too soon. This happens if the knife is not well made, or if it is not steadily pushed on while making the section; or during a sudden movement of the eye. In these cases we withdraw the knife and complete the section with strong blunt-pointed strabismus scissors. Corneal incisions thus made heal readily. If we do not wish to withdraw the knife, and the iris places itself over the edge of the knife, we gently press with the forefinger (which assists in raising the upper lid) upon the cornea. The pressure is kept up until the section is almost completed. If the iris cannot be pushed back, we cut through it, or withdraw the knife, and finish the section with scissors. If the iris has been much bruised we excise the bruised portion.

(2.) If the margin of the pupil, or some other portion of the iris, has been wounded, bleeding occasionally occurs into the aqueous chamber.

This is of little consequence, unless the iris has been bruised, when the bruised part should be excised, to avoid iritis.

(3.) If a second pupil has been formed, by some marginal portion of iris having been cut away, the intervening bridge of iris must be divided with scissors before opening the capsule. We thus avoid the cataract becoming entangled in the new pupil.

(4.) The iris, after completing the corneal section, may "bulge," i. e. may project slightly and push the margins of the corneal incision asunder. This, if posterior synechiæ exist, may be caused by aqueous humour accumulated behind the iris. An iridectomy should be performed.

If the apparently healthy iris "bulges," there being neither straining nor pressure upon the eye from without, we must be prepared for a troublesome course. The bulging is the result of undue tension of the eye, and escape of vitreous, &c., threatens.

The patient must be particularly careful, during the further steps of the operation, not to strain; and all pressure upon the eye should be avoided.

If in these cases we perform iridectomy of the bulging portion of iris the greatest delicacy is required lest vitreous be lost.

The cataract may not escape—

(1.) From the corneal incision being too small. The incision may be too slanting, or generally too small, so that even much pressure does not cause the cataract to escape. The incision must be enlarged (with strong blunt-pointed scissors) if the cataract does not escape readily.

(2.) From the pupil not dilating. If, previous to the operation, the pupil resists atropia, iridectomy should be performed before opening the capsule. This accident rarely happens: it is observed in highly-presbyopic persons, and in persons suffering from cerebral changes, e. g. from the effects of apoplexy. Both pupils are generally contracted, and resist the action of atropia.

(3.) From being adherent to the capsule,—as has been observed in cataract with dead-white superficial spots, and in traumatic cataract. Removal of the capsule with the sharp hook becomes necessary.

"Vitreous" substance may escape—

(1.) Before the cataract is removed, sometimes even before the capsule has been lacerated. This may occur if the section is carried too near the ciliary processes, if the patient strains much; or after the capsule is opened, if too much pressure is made upon the eye. The vitreous in these cases bursts through the suspensory ligament, and the cataract sinks back behind the iris. To prevent this, the scoop should be rapidly carried through the pupil behind the iris and cataract. The latter must be removed, however much "vitreous" may be lost. Loss of vision, through glaucomatous changes or suppuration of the eyeball, follows if the cataract be allowed to remain in the vitreous chamber.

(2.) "Vitreous" may escape with the cataract, or immediately after its removal, through straining of the patient, or through too sudden completion of the section.

The lids should at once be closed, and a sponge dipped into cold water placed upon them. After a few minutes the lids are raised carefully to see whether the corneal flap is doubled down. If so, we pass the curette gently beneath the slightly raised upper lid, and along the curvature of the cornea, so as to bring the flap into a more natural position; having succeeded in this, we at once close the lids, and apply a bandage with wet lint.

The cataract escapes enclosed in its capsule if too great pressure is made upon the eye, or if the patient strains much. This is of no consequence if no "vitreous" is lost. The unfavourable consequences, if vitreous is lost, may be—partial displacement of retina,—hæmorrhage between choroid and sclerotic, more particularly in the region of the ciliary processes, followed by more or less shrinking of the eyeball, or more or less severe inflammation.

"Vitreous" may escape though there be no straining, and no fault committed by the operator.

(1.) This, if the "vitreous" has the natural consistence, or is too firm, is a sign of the eye being glaucomatous. Due regard to the tension may assist us in avoiding this grave accident. It occurs more particularly in persons with very large and hard arteries, and in persons with very white hair. The iris bulges, and the cataract escapes as soon as the corneal incision is finished, or immediately after the capsule is opened; "vitreous" follows immediately, or a few seconds later. The patient at the same time complains of severe pain in the eyeball, which is caused by sudden displacement of the ciliary nerves. Blood oozes out through the corneal wound as soon as all the vitreous has escaped. On making a section of the eye, we find the retina and choroid separated from the sclerotic (except at the optic disc and near the ciliary muscle) by coagulated and fluid blood. The accident has repeatedly occurred in both eyes. Vision is lost; and the eye, if not removed at once, remains often painful for weeks, until it gradually shrinks.

(2.) If the "vitreous" is fluid and the tunics collapse little need be feared. It is only when the curvature of the tunics remains unaltered that intra-ocular hæmorrhage need be expected. The tunics of both eyes may collapse completely, and be thrown into folds without their relative position being disturbed. All fluid occupying the vitreous chamber may escape; and twelve hours later we may find the natural curvature of the tunics restored, through fluid again filling the vitreous chamber. Good vision is generally obtained. In these cases, after the cataract is removed, some wet lint, dipped into tepid water, should be tied over the

closed lids, so as to exercise very slight pressure, while the patient, for from 24 to 48 hours, is kept in bed.

(3.) The area of the pupil remains grey and opaque, through soft portions of cataract having been left after removal of the nucleus. The more glutinous the soft part of the cataract is the less readily does it escape. If it does not come away easily by using the syringe or the scoop, no further attempts at removal should be made. We must be prepared for iritis, or for a more protracted recovery. Particles of the nucleus, if soft and left behind, may become absorbed without further disturbance; if hard, they often cause iritis (within twenty-four to sixty hours), which reaches its height from the fourth to seventh day after the operation. We must prepare for this if, from the irregular shape of the hard nucleus, we infer such particles to have remained behind.

Treatment after the operation, supposing no accident to have occurred.

The patient should occupy a well ventilated room, which is still sufficiently light to allow of our seeing the colour of the skin of the eyelids, and applying the wet lint securely.

The patient is placed in the position which is most comfortable, and is told to avoid undue muscular efforts, and all unnecessary movement. The uppermost piece of wet lint is changed every quarter of an hour until bed-time.

No food requiring mastication is allowed during the first twenty-four hours. Broth, beef-tea, wine, eggs, vegetables may be given; and solid animal food (finely minced meat) on the second day. Spirits or beer may be allowed to those who are in the habit of having them.

The patient should be prevented for the first five days from touching the eyes during sleep, by having the bed covering stitched to the pillow, allowing sufficient room to turn round, but not to bring the hands up to the face. Should this be found inconvenient, the patient must be watched for four or five nights. The wet lint placed on the lids is secured with a bandage during sleep. Restless persons may require a narcotic. The patient has to remain in bed for from 36 to 48 hours. The next five days he may remain up a few hours in the middle of the day, having the lids bound up with wet lint. The application of wet lint is repeated frequently during one hour after breakfast, and during several hours before going to sleep.

The outward appearance of the lids, the quality of the discharge, and the presence of pain, are the guides which we have as to the necessity of examining the eye.

The eye is doing well if the colour of the lids (especially of the upper

lid) is not changed, or their margins only slightly reddened ; and if there is only slight watery or mucous discharge and no pain. In this case we inspect the eye on the eighth day after the operation. The incision frequently has healed on the second or third day.

We may find, (1.) Slight or no redness of the conjunctiva ; the incision healed, and the line of incision smooth, or very slightly uneven ; the anterior chamber good, and the pupil clear and central, or slightly displaced towards the section.

(2.) Or we may find all as just mentioned, except no anterior chamber, the iris resting against the cornea. In this case a bandage is applied over the closed eyelids *until the section has healed completely* and the anterior chamber has become restored. In rare cases four or six weeks may elapse before the union is complete.

(3.) We may find some sclerotic redness, the pupil occupied by opaque matter, and all other parts healthy; in which case a bandage over the closed lids and atropia are made use of, the latter being applied every third hour during the day until the pupil appears clear, or nearly so. The eye operated upon may be used as soon as all sclerotic redness and intolerance of light have ceased. A shade must be worn, or the eye kept closed and not exposed to bright light, as long as there is the slightest intolerance of light.

Atropia is applied to the eye not operated on once daily. Twenty-four hours after the operation it may be allowed to remain open with a shade over it. It must again be closed if keeping it open gives rise to uneasiness.

This favourable progress of the eye operated upon is by no means the rule. Generally a pricking sensation or pain is complained of a few hours after the operation, especially when moving the eyeball. The pain ceases, or is temporarily relieved, by escape of tears.

Lint dipped into cold water must, in this case, be applied more frequently to the closed lids, even until late at night. The frequent application of wet lint, if pleasant to the patient, is continued on the following days.

Swelling and redness of the lids, and pain in the eye or "over the eyebrow," are certain signs of undue inflammation. We must, whenever they appear, carefully (and without exposing the eye operated upon to more light than is necessary) inspect the cornea and iris.

We may find, (1.) Prolapse of the iris. This is readily recognized by a change in the curvature of the cornea. The margins of the incision are not in apposition with each other, but are pushed asunder by a dark substance (the iris next the section) which projects more or less. The pupil is drawn up, and often disappears behind the margin of the cornea.

It much depends upon the general health of the patient, and upon the condition of the eye previous to the operation, whether the prolapse (being a great source of irritation) gives rise to inflammation, and if so, to what

kind. If left alone the prolapse generally disappears spontaneously accompanied by great pain and prolonged irritation. It should, however, as soon as its presence is ascertained, be either treated by—

(*a.*) Puncturing and then touching with the solid nitrate of silver. This is useful if aqueous humour or swollen particles of cataract are in contact with the bulging iris. Touching with caustic has been followed by severe inflammation, if the prolapse has been caused by protrusion of "vitreous." Pressure upon the closed lids, by means of a bandage and wet lint, must be kept up for several weeks. The operation of puncturing and touching with caustic may have to be repeated if the prolapse has not subsided after one application.

Or by—

(*b.*) Snipping off the prolapse with scissors. This, if followed by loss of vitreous or by fistula, may lead to shrinking of the eye. A satisfactory result has in many cases been obtained (especially where the pupil has been much displaced towards the section) by first (under chloroform) "making an artificial pupil" downwards, supposing the prolapse to be upwards, and then by removing the prolapse with forceps and scissors. In doing this, care must be taken to leave a narrow rim of iris along the base of the prolapse, to secure ready union. After the operation both eyes are kept bound up with wet lint; the lint has to be changed frequently until the anterior chamber is restored.

(2.) We may find the incision healed, its margins hazy, the aqueous humour slightly turbid, the pupil somewhat irregular and occupied by opaque matter, the tension of the eye normal or slightly increased, and perception of light normal. Locally, we treat as in iritis, i. e. order four to six leeches to be applied to the corresponding temple, if the pain is at all considerable, and atropia to be used every second hour during the day. Lint dipped into cold or warm water (according to the feelings of the patient) is applied frequently to the closed lids of both eyes.

Suppuration of the incision may set in even as late as two or three weeks after the operation. It may occur while union is going on, or after it is completed.

(3.) Suppuration may extend from the incision. The cornea becomes grey, or yellowish and opaque. This is accompanied by increased swelling and redness of the lids; by chemosis especially round the incision, with more or less mucopurulent discharge; by pain in the eye and over the corresponding side of the head, &c. The suppurative inflammation subsides in about eight weeks, if it remains confined to the cornea, or cornea and iris. The cornea remains opaque and adherent to the iris; part of it may recover its transparency. If the cornea sloughs a cicatrix follows which sometimes becomes staphylomatous. The patient retains perception of light.

The suppuration sometimes extends to the "vitreous," choroid, and retina. (See Ophthalmitis.) This grave result occurs in the Hospital in about three per cent. of the cases operated upon by extraction.

The suppuration may commence in the ciliary processes and in the adjoining vitreous, and thence extend. A yellow reflection from behind the pupil indicates the presence of pus. Suppuration of the iris and cornea soon follow.

In rare cases a form of corneo-iritis appears, which resembles the one observed in persons who suffer from inherited syphilis, and should be treated as such.

In old or badly-nourished patients suppuration of the cornea may appear without any pain, with little swelling of the lids, and with severe purulent discharge from the conjunctiva. In such when examining the eye on the second or third day after the operation we find chemosis, and the cornea changed into a yellow opaque substance. The eye gradually shrinks.

By the frequent application of lint (dipped into warm water) to the closed eyelids, and by generous diet, we may succeed in confining the suppuration to the cornea, and in retaining good perception of light.

Removal of Cataract by the Scoop. ("By Traction.") Scoop Extraction.

The object of this mode of operating is to remove the cataract with the aid of a scoop, through a smaller incision in the cornea than is made for common extraction. The removal of the cataract is preceded by iridectomy.

The advantages are:—(1.) That we can give chloroform with greater safety, as regards the eye. (2.) That we avoid the complications arising from prolapse of the iris, and derive the advantages of an iridectomy as regards the tension of the eye. (3.) That the cataract can be removed more completely.

The disadvantages of an irregular pupil, if the iridectomy be not made upwards, can partly be counteracted by properly arranged spectacles: the iridectomy, if made upwards, creates but little inconvenience.

Operation.

The patient, being under the influence of chloroform, is placed as for extraction of cataract. The eyelids are kept open with a light stop speculum, and the eyeball is fixed with the forceps opposite the point where we propose commencing the incision. The incision should have a length of from three to five lines, according to the size of the nucleus of the cataract. It should always be large enough to allow of easy removal of the cataract.

It should commence in the sclerotic, at the margin of the cornea; its extremities should lie in front of the iris in the sclerotic adjoining the cornea. It thus forms a somewhat greater arc than the margin of the cornea. Those who are in the habit of performing eye operations make the incision along the upper margin of the cornea; it is however easier to make it along the outer margin. The straight or the bent lancet-shaped knife (largest size), the point entering at the extreme margin of the anterior chamber, is steadily pushed on into the anterior chamber (the point being directed very slightly forwards) until the incision has the desired length. Should the point have reached the opposite cornea before this is attained, then the incision is enlarged while withdrawing the knife, or afterwards with strong blunt-pointed scissors. Care should be taken not to wound the iris or the capsule of the lens.

Iridectomy is then performed. The portion of iris excised should be sufficiently large to prevent our bruising the remainder during further manipulations. Blood in the chamber should as far as possible be removed before proceeding to the laceration of the capsule and to the removal of the cataract.

During the removal of the cataract the patient should be thoroughly under the influence of chloroform.

The aqueous humour having escaped and the iridectomy having been performed, the operator fixes the eye himself, and with the sharp hook or the pricker proceeds to the opening of the capsule.

The sharp hook (or the pricker) is passed through the incision over the surface of the capsule to the spot where we wish to make the first opening. It is best to lacerate the capsule first along the margin of the lens which lies farthest from the incision. There the point is thrust through the capsule. Afterwards the other portions of the capsule are freely lacerated. To do this without wounding other parts, we must be familiar with the shape and size of the lens. While opening the capsule we must neither bruise the iris nor displace the cataract. The part of the capsule next the incision is opened last. We sometimes succeed in withdrawing the capsule with the sharp hook.

While opening the capsule attention should be paid to the consistence of the cataract, and to the size of the nucleus. The spontaneous escape of soft opaque matter should be encouraged by gentle pressure upon the eyeball.

The nucleus can often be removed by passing the sharp hook behind and into it, and then withdrawing it. The sharp hook must be withdrawn if we do not readily succeed in removing the nucleus of the cataract, and the scoop must be made use of. If the pricker is used for lacerating the capsule, we withdraw it, after having freely opened the capsule, and if necessary loosened the nucleus.

Knowing the size, shape, and position of the nucleus of the cataract, our next object is to pass the scoop between the capsule and the nucleus. Having succeeded in passing the scoop through the wound in the cornea, and through the pupil into the cataract and behind the nucleus, we gently press the scoop and nucleus forwards into the area of the pupil, and then slowly withdraw both from the eye. During these manipulations *all pressure upon the iris or cornea* should be avoided.

The entire nucleus having been withdrawn, we remove the speculum, close the lids, and gently rub the upper lid over the cornea, so as to cause softer portions of cataract, which may have been left behind the iris, to advance into the area of the pupil. If any are visible we remove them with the scoop or syringe, as in extraction of soft cataract. Portions of the nucleus are sometimes broken off, if the incision has been made too small or too much force has been used while withdrawing the nucleus. This must be ascertained by examining the nucleus which has been removed. All particles of the nucleus should be removed with the scoop.

Accidents during the operation.

(1.) If the incision is too small to allow the scoop, or the scoop and nucleus, to pass, the scoop must be withdrawn and the incision enlarged with the knife, or with scissors, after which the scoop is reintroduced, and the nucleus removed.

(2.) The scoop, instead of passing behind the nucleus, may push the entire cataract towards the opposite side. Insufficient opening of the capsule (especially if thickened), or a glutinous (normal) consistence of the superficial portion of the lens, or insufficient loosening of the nucleus, may cause this. The scoop should be withdrawn, the capsule opened freely, and the nucleus freed with the sharp hook or pricker.

(3.) Portions of the nucleus may be broken off, and left behind, especially if force has been used while withdrawing the nucleus. We should endeavour as much as possible to remove these portions with a small scoop, and if unsuccessful, take the necessary steps to prevent the occurrence of inflammation; apply leeches, though there may be no inflammation as yet, &c., &c.

(4.) Vitreous may escape before the capsule has been opened. This may happen if the incision is made too far behind the margin of the cornea; or it may occur immediately after the iridectomy (if the patient is straining), or while attempting to introduce the scoop behind the nucleus. Some operators rapidly introduce a large scoop into the vitreous chamber behind the cataract, and withdraw the cataract with or without its capsule. Others remove the speculum, close the lids, and leave the cataract until the incision has healed, and the parts have returned to their natural

positions. The latter proceeding is preferable if the vitreous escapes before the capsule has been opened. If it escapes during or after removal of the nucleus no attempts should be made to remove particles of cataract that may be lodged behind the iris. Those particles which are visible should be left, if soft; if hard, they should be removed with the scoop, syringe, or forceps.

The escape of vitreous is frequently followed by more or less inflammation; and sometimes by suppuration of the eyeball. From six to eight leeches should be applied to the temple of the eye operated upon the evening after the operation. Pieces of lint, dipped into iced water, are applied frequently to the closed lids of both eyes, and atropia is made use of, as in severe iritis.

Depression of Cataract. Reclination. Couching.

The object of the operation is to displace the lens into the vitreous chamber away from the area of the pupil. In half the number of cases operated on in this manner the result has been unfavourable. While where the cataract has been removed from the eye, out of 100 eyes certainly 85 have obtained useful vision, while only about three per cent. have lost vision completely.

Vision often begins to fail in from three months to from three to four years after the operation, if it is not lost at once by inflammation.

Causes of failure of the operation are :—

(1.) The cataract rising again, having only in part become absorbed, or not at all.

(2.) Inflammation round the non-depressed portions.

(3.) The displaced cataract acting as a foreign body (this is the most common cause of failure), and giving rise to glaucoma, or to exudation upon the ciliary processes, with displacement of the adjoining retina.

Operation.

The patient and the operator are placed as for extraction; the pupil being dilated by atropia, the eyelids are kept open by the wire-speculum, and the eyeball is "fixed" with the forceps. A "couching needle" is thrust through the sclerotic near the outer and lower margin of the cornea. It is pushed on behind the iris until its point appears in the area of the pupil. The broad surface of the needle is then placed upon the cataract a little above its anterior pole. By steady pressure backwards and downwards the cataract is displaced into the vitreous chamber. It should not come in contact with the retina or with the ciliary processes. It should rest in the vitreous chamber, with its anterior surface directed upwards. As much as possible of the capsule should be depressed with the cataract. Some at

first break up the vitreous to "prepare a bed for the cataract." Soft portions of cataract, which may have remained behind the pupil, are left undisturbed. It suffices to have depressed the hard nucleus.

Accidents.—The needle, if it becomes entangled in the nucleus of the cataract, has to be withdrawn and reintroduced in a better direction.

The consistence of the vitreous substance may impede the displacement of the cataract. In this case we continue pressing in the proper direction until the cataract has disappeared from behind the pupil. If the cataract has been displaced into the anterior chamber, and we do not succeed readily in pushing it back through the pupil, it must be removed through an incision in the cornea. The cataract has to be extracted if it should rise again. An iridectomy with extraction of the displaced cataract from the vitreous chamber is the last resource if glaucomatous changes appear.

REMOVAL OF CATARACT BY ABSORPTION. (*Solution. Discission. Keratonixis.*)

This mode of treatment takes advantage of the power which the "eye" possesses to absorb the cataract when brought in immediate contact with the aqueous humour.

The operation is indicated—(1.) In persons below the age of fifteen.

(2.) In soft cataract, especially with broad opaque striæ, if the pupil responds well to atropia.

(3.) In persons of all ages, if the nucleus of the lens is not too hard, only one eye affected, and slowness of recovery of no consequence.

Linear or scoop extraction may have to follow the operation if it is desirable to hasten the removal of the cataract; or if through iritis the capsule has become thickened, or the pupil closed.

The operation should be combined with iridectomy—(1.) If much of the lens is transparent, or if the cataract has the consistence of the healthy lens. In both cases much swelling of the lens must be expected. (2.) If the centre of the lens is hard. (3.) If the pupil is small, and but little influenced by atropia. (4.) If glaucomatous symptoms appear.

The Operation.

Restless patients are placed under chloroform. In all cases the eyelids are kept open by the wire-speculum and the eyeball is fixed by forceps.

A "cataract needle" is thrust through the cornea (about one-eighth of an inch from its margin) into the anterior chamber, and pushed on until its point has passed a little beyond the middle of the previously dilated pupil.

The point of the needle is at that spot thrust through the capsule. No resistance, or hardly any, is felt when doing this.

A well-dilated pupil is a favourable symptom, since complications are less likely to arise from the contact of particles of cataract with the iris.

The manipulations with the needle can be carried out with much greater precision when using lateral illumination. The object of these manipulations is to make several incisions into the cataract. The incisions should converge towards and pass into the first puncture of the capsule. By these incisions the capsule is freely opened round the anterior pole of the lens.

After having made the first incision, we withdraw the point of the needle from the cataract, carry it over the surface of the capsule to a point situated more eccentrically; thrust it again through the capsule, and carry this incision into the first one. In this way from four to six incisions are made to converge into the first one.

The entire anterior surface of the capsule and of the cataract may be broken up at once if an iridectomy has been performed before the needle operation. Large incisions should also be made if iritis has preceded the cataract, since the capsule is often thickened, or has lost its elasticity. The more the capsule is lacerated the better is the cataract exposed to the contact of the aqueous humour, and the more complete is its absorption. Capsular obstructions are also less likely to occur. Free laceration of the capsule, however, is accompanied by considerable swelling of the cataract. Contact of the cataract with the iris and ciliary processes is in many cases the cause of unfavourable complications. It is therefore safer, by the first needle operation, only to break up the capsule and lens at and near the anterior pole, and not to carry the incisions too deep.

In children the entire lens is often broken up at once, and with impunity, though in these also it is safer to proceed as indicated above. In older persons even small particles of cataract, when coming in contact with the iris, or ciliary processes, may give rise to severe inflammation.

The incisions into the capsule, as a rule, become enlarged spontaneously through swelling of the cataract. A few days after the operation we find grey and opaque flocculi projecting from the wound in the capsule. The centre (nucleus) of the lens, or some segment of it, occasionally falls into the anterior chamber. Hard nuclei swell out but little, and become absorbed very slowly: if they give rise to iritis they should be removed by extraction.

The time necessary for absorption varies from four weeks to nine months. The softer the cataract, the remainder of the eye being sound, the quicker is the absorption.

The more glutinous or transparent the lens, the more swelling may be expected when it becomes opaque.

Accidents during the operation, and after treatment.

(1.) The aqueous humour may escape before the needle has reached the cataract; in which case the pupil becomes contracted. This happens if the needle is not well made, or if the patient suddenly moves the eye, so as to cause the needle to escape from the aqueous chamber. In this case we break up the surface of the cataract, which lies in the area of the contracted pupil; being careful neither to stretch nor to scrape the iris.

(2.) Puncture of the iris with the needle is of no consequence.

(3.) The capsule of the cataract may be so tough that we are unable to tear it readily with the needle. In this case an incision should be made through the cornea, and the capsule extracted with the sharp hook.

(4.) Breaking through the hyaloid fossa with the needle. This allows the vitreous to advance into the pupil. The latter suddenly becomes clear.

This accident is followed by more or less inflammation, and requires the treatment which would be adopted for severe iritis.

The absorption may be arrested—

(1.) Through the wound in the capsule being too small, or becoming closed by transparent newly-formed substance. Absorption is progressing as long as opaque flocculi can be perceived in the pupil. A second needle operation becomes necessary only when the area of the pupil has assumed an uniformly smooth and opaque appearance.

(2.) Through iritis. This is by far the most common cause. Iridectomy with extraction through a small opening in the cornea should be performed after the iritis has completely subsided under treatment.

During absorption, only slightly increased vascularity, with some watering, and intolerance of light should appear. The pupil should be well dilated by atropia; and the eye operated upon kept bound up until all intolerance of light has ceased.

Suppurative iritis or choroiditis or even ophthalmitis may occur. Slight iritis, leading to posterior synechiæ, is quite the rule, however carefully the after treatment may have been conducted.

The usual cause of inflammation, especially of iritis, must be sought in the irritation produced by portions of cataract coming in contact with the iris or ciliary processes. The tendency to inflammation varies much. In one case suppuration of the iris may follow after one carefully performed needle operation; in another case, as many as twenty needle operations, each followed by some iritis, may result in useful vision.

The patient, after the operation, is kept in bed for 36 hours; and lint, moistened with cold water, is applied frequently to the closed eyelids, especially in the evening. Atropia is applied to both eyes three times daily. The eye operated upon is kept closed; and a shade is worn over both eyes *until all intolerance of light has ceased.*

One needle operation may suffice to induce complete absorption of the cataract. By some as many as twenty have been deemed necessary on one eye.

Iritis may set in a few days after the operation, or six or eight weeks later, or as long as larger portions of the cataract are left for absorption. We, therefore, should keep sight of our patient, and at once adopt the treatment of iritis, if severe pain is complained of over the eyebrow and in the temple of the eye operated upon, with watering and intolerance of light.

Most of the complications arising from iritis are avoided by a timely iridectomy, and by the frequent use of atropia.

Spectacles may be given for near work as soon as the area behind the pupil has become clear, and all intolerance of light has ceased. Frequently no spectacles need be worn for going about.

Removal of Cataract by Linear Extraction.

The operation is indicated—

In cataract without a hard nucleus, i. e. as a rule in cataract occurring in persons below forty.

The object of the operation is to remove the soft cataract,—whether rendered soft by nature or by art,—through a small incision in the cornea. Many perform iridectomy immediately, or several weeks, previous to the linear extraction.

Operation.

The patient, if quiet, need not take chloroform. A lancet-shaped knife is thrust through the cornea (at abou $\frac{1}{10}$ in. from its outer and upper margin) into the anterior chamber, and an incision about $\frac{1}{5}$ in. in width is made. While slowly withdrawing the knife the aqueous humour, and generally some of the cataract, escape through the incision, if the capsule of the lens has also been incised while making the corneal incision. Gentle pressure upon the eyeball, with the forceps which fixes it, or friction of the closed eyelids against the eye, assists in removing the rest of the cataract. Portions which do not readily escape by these means should be removed by suction.

Particles of chalk mixed up with lens matter, when left in the anterior chamber, may set up iritis. They should be removed with the scoop, forceps, or syringe.

If the capsule has not been opened previous to nor while making the incision into the cornea, this should be done with the pricker as in extraction, or better with the sharp hook after completing the incision. The capsule should, if possible, be withdrawn with the iris forceps, or with the sharp hook. This may be done either before or after the

removal of the opaque lens matter, care being taken not to encourage the escape of vitreous substance.

Accidents during the operation.

(1.) The consistence of the cataract may have been mistaken, and none or only a small quantity may have escaped by the means indicated above. In this case no force must be used to remove the cataract, but iridectomy upwards should be performed. The eye must be watched carefully, and treated as after extraction, the rest of the cataract being left to become absorbed, or to be removed a week or fortnight later, after it has become more fluid.

(2.) Prolapse of the iris, or anterior synechiæ. This accident and its complications are avoided by iridectomy. The protruding iris is removed with forceps and scissors, if friction of the eye with the eyelid does not cause it to recede. The same proceeding is adopted if the prolapse occurs some time after the operation, and if it does not subside on the application of Calabar.

Most accidents arising from the iris are avoided by iridectomy performed at the time of, or previous to, the extraction.

(3.) Spontaneous bleeding from the iris. The blood, if it does not escape readily by the use of the scoop or syringe, must be left to be absorbed.

(4.) The vitreous substance may advance into or through the pupil (the occurrence of this accident is characterized by the area of the pupil suddenly becoming "black"); or the "vitreous" may even escape through the incision. It always displaces particles of cataract behind the iris. Attempts to remove small particles are useless. The termination of these cases is more favourable if iridectomy has been combined with the extraction. Severe pain in the eye and corresponding side of the forehead, and even attacks of vomiting, often follow. Iritis frequently appears about the third or fourth day after the accident. Sometimes it is followed by suppuration of the iris and cornea, or by ophthalmitis.

In rare cases the pupil (with its margin pushed back) remains irregularly dilated, but clear. The margin of the pupil probably becomes adherent to the vitreous substance. This state, with a good anterior chamber, with slight intolerance of light, and with some increase of tension, continues in some cases for six or eight months. In the majority of cases, the vitreous substance after from twelve to twenty-four hours (during which the pain continues more or less) recedes behind the pupil. The patient must remain in bed; and ice, or applications of cold water, must be used very frequently to the closed eyelids of both eyes, together with atropia every second hour during the day, until all pain has subsided.

CAPSULAR OBSTRUCTIONS.

(*"Capsular Opacities." "Opaque Capsule."*) *False Membrane. Opacities behind the Pupil.*

We distinguish the following capsular obstructions—

(1.) Those which precede the removal of cataract; and (2.) those which follow that operation.

Changes accompanied by inflammation near the surfaces of the capsule give rise to opaque spots upon those surfaces; e. g. if, during purulent ophthalmia, the lens and its capsule come into contact with the swollen suppurating cornea (whether perforation occur or not), opaque spots upon the surfaces of the capsule may follow.

The anterior polar or pyramidal cataract, situated on the outer surface of the anterior capsule, and projecting through the pupil, is of this origin. Ulceration of the cornea, wounds of the capsule, iritis, cyclitis, &c., may give rise to opaque spots, which, as dissection shows, are due to an alteration in shape and transparency of the intracapsular cells. These, instead of developing into lens fibres, grow out into differently-shaped cells. Particles of chalk and spicules of bone have been found in such opaque spots.

On the outer surface of the anterior capsule, and in its substance, have been found globules of a yellowish, translucent, finely-granular substance, in appearance, and chemically, resembling that of the capsule itself.

Opaque warty globular "excrescences" and deposits of lime in grains, globules, &c., if considerable, appear to the naked eye as radiating or irregular white, or grey and opaque, streaks or dots. Posterior synechiæ, corneal opacities, and other signs of passed inflammation often occur simultaneously. Spots of brown or black pigment, or vascular or non-vascular opacities, derived from the iris (with or without synechiæ), are common complications of capsular opacities.

The opacities just described may be present without any other alteration in transparency of the lens; or may remain after the lens, or part of it, has been removed.

The opacities observed after the removal of cataract are chiefly caused by "opaque lens matter," which has not been removed; or has not become absorbed; or being transparent at the time of operation, has subsequently become opaque.

If the anterior capsule is freely opened, and the entire lens removed, and no inflammation follows, no opacities occur behind the pupil. The anterior capsule retracts towards the suspensory ligament, and the transparent posterior capsule is slightly bulged forwards. This favourable result, un-

less the anterior capsule be entirely removed, is hardly ever obtained, however good vision may be. We mostly find, on dilating the pupil, an opaque white rim of varying width near the tips of the ciliary processes. This rim consists of débris of cataract, enclosed within the capsule. It need not be disturbed as long as the area of the pupil is clear, and the transparency and smoothness of the posterior capsule are not altered.

Opaque deposits upon the surfaces of the capsule occur whenever inflammation (iritis, cyclitis, &c.), however slight, follow the operations for cataract. They retard or prevent the absorption of opaque lens matter, render the capsule stiff, and are the means of adhesions between it and the adjoining iris.

Minute examination of sections of "opaque capsule," the result of one or of several of the above causes, shows that in all instances the capsule can be traced as a transparent line across the opaque substance. When using the term "opaque capsule" in these cases, we do not mean an opacity of the capsule itself, but a deposit of opaque lens matter, of chalk-granules, of connective tissue, &c., upon the surfaces of the transparent capsule.

Treatment.

The removal of capsular obstructions, especially if performed roughly, is not without danger. Eyes with useful vision have been lost in consequence of glaucomatous changes, or suppuration, or intracular hæmorrhage, or displaced retina, or severe iritis, with closure of pupil.

Among the accidents which may give rise to these unfavourable results are—separation (by the instrument used for the operation) of the suspensory ligament and of the adjoining retina from the choroid;—laceration of the ciliary processes, and hæmorrhage into the vitreous chamber;—laceration of the vitreous substance, causing the latter to advance through the pupil into the anterior chamber. The latter accident is sometimes complicated with hæmorrhage between the choroid and sclerotic, and glaucomatous symptoms ensue.

We should leave the capsular obstruction undisturbed as long as the capsule and the opacities attached to it do not prevent vision, i. e. as long as the patient can read ordinary type. The removal of such obstructions, whether opaque or transparent, while the eye is irritable, intolerant of light, or inflamed, is often followed by iritis, or by hæmorrhage, and by fresh opaque deposit.

The removal of capsular obstructions, which follow depression of cataract, most frequently gives rise to severe inflammation. Those who perform depression advise, unless vision be materially impaired, not to interfere with the obstructions.

It is safest to perform the operation of removing capsular obstructions

when the eye is entirely free from all undue vascularity, and when it is of normal tension, and possesses good perception of light in all parts of the retina.

The only obstructions requiring removal are those which lie in the area of the pupil; and only as much need be removed as is equal to the size of a pupil of medium dilatation.

The Operation.

The pupil having been dilated as much as possible by atropia, and the patient placed as for extraction of cataract, chloroform is given if the patient is at all inclined to be restless. The lids are kept open with a stop-speculum, and the eyeball is well steadied by the operator before attacking the capsule. An assistant, standing at the side of the patient with a convex lens of from three to four inch focal distance, concentrates the light of a lamp upon the portion of capsule we propose removing. A careful examination of the capsule, of its relation to the parts surrounding it, and of the portion we wish to remove, should immediately precede the operation. All steps which may give rise to bleeding should be avoided; or if unavoidable, should only be taken after removal of the obstruction. Softish eyes, and those in which, after long-continued choroido-iritis, the parts within the eye have lost their elasticity, are most inclined to bleed. The blood, which becomes accumulated in the anterior chamber, in these cases proceeds from vessels of the conjunctiva, or of the iris or capsule; and bleeding is often avoided by making the incision through a transparent part of the cornea. The vitreous substance is least disturbed, while removing capsular obstructions, by moving the instrument, needle, &c., as much as possible in a plane with the portion of capsule which we wish to withdraw.

Folds of transparent capsule should be torn through with one or two needles. Suppose such folds to have a vertical direction, and we propose dividing them with a cutting needle, we pass the needle through the cornea near its upper margin, carry the point up to and through the folds near the inner margin of the pupil, and thence horizontally across the folds, dividing them with the cutting part of the needle as far as the outer margin of the pupil. We then, having obtained a transverse clear slit in the folded capsule, withdraw the needle, if possible without losing any aqueous humour.

Opaque filaments, stretched across behind the area of the pupil, may in the same way be divided with one or two needles. The divided portions are expected at once, or after some weeks, to shrink away from behind the area of the pupil.

When using two needles some practice is required to keep the at-

tention fixed on both. Suppose we have not succeeded with one needle in dividing an opaque filament, which e. g. extends horizontally across the area of the pupil, we then, without withdrawing the first, introduce a second needle. The first needle, having been thrust through the cornea near its upper margin, and the point having been carried a little beyond the opaque filament and in front of it, the second needle is thrust through the cornea near its lower margin, and the point is carried behind and a little beyond the filament. The points of the two needles are then rotated round each other, so as to cause the elastic filament to become twisted once or twice round the stems of the needles. By drawing the points in opposite directions the filament is torn through.

Opaque capsular obstructions which are too large to be cut through with one or two needles, are removed with the sharp hook. To do this an incision is made through the cornea near its margin, and opposite to the spot where the capsule appears thinnest, or its attachments to the surrounding parts are least thickened by previous inflammation. The sharp hook is then introduced (in the same manner as a blunt iris hook) up to and through the part of the opaque capsule which lies farthest from the incision in the cornea. The capsule is gently torn away from its attachment, and either drawn out through the incision, or, if too firmly attached near the incision, it is drawn out as much as possible, and cut off; the rest is pushed back "into the eye."

The opaque capsule need not be removed from the eye if a clear pupil, about the size of a natural one, has been obtained by merely tearing the capsule away from its insertion opposite the incision; and if at the time of operation it shows no tendency to return to its former place. If the attachments of the capsule are so firm that considerable force is necessary to tear them with the hook, or if, while attempting to do so, the sclerotic next the hook is drawn in, we take a small sharp lancet-shaped knife, and thrust it through the cornea and capsule into the vitreous chamber between the hook and the part of the sclerotic thus drawn in. Then having cut through the firmly attached part of the capsule, we quickly withdraw the knife, and having with the other hand held the hook inserted into the capsule, withdraw the latter.

The pupil, though much of the capsule and iris may have been removed, may become closed by blood and fibrin ; or may become contracted again, though no hæmorrhage has occurred. This happens often in eyes which have suffered from severe choroido-iritis, and in those in which an inflammation, following operation, has not completely subsided. Good vision has been obtained in such cases by counteracting the tendency to contraction by a T-shaped incision through all the parts which separate the anterior (aqueous) from the vitreous chamber. To effect this we thrust a lancet-shaped knife through the cornea close to its margin, and through the ad-

joining iris and capsule into the vitreous chamber, then withdraw the knife quickly, and introduce a pair of strong iris scissors through the incision in the cornea. In the anterior chamber we open the scissors, and pass one blade through the incision in the iris and capsule into the vitreous chamber, the other in front of the iris; we next push on both blades until the one in the anterior chamber has nearly reached the opposite margin of the cornea, and then cut through all the parts which lie between the blades.

Most of the above operations are attended with loss, or at least with displacement or disturbance, of some of the vitreous substance. To avoid inflammation and complications arising from sickness, we apply atropia to the eye not operated on, tie wet lint over the closed lids of both eyes, and keep both eyes at rest and the eye operated upon closed, until all intolerance of light and other signs of irritation have ceased.

Congenital Cataract and Cataract in Children.

Causes and general remarks.

In a few instances congenital cataract has been observed in one eye only. Its most frequent cause appears to be inherited syphilis (with or without traces of iritis).

Peculiarities in the shape of the head; in the colour, &c., of the incisor teeth, which may be of the notched syphilitic kind, or may present nodular uneven surfaces (so called "rocky teeth)," are observed in most cases. As many as six cases of congenital cataract have occurred in one family.

A frequent cause of cataract in children is purulent ophthalmia. An opaque white nodular deposit, at or near the anterior pole, with the lens otherwise transparent, and opacity of the entire lens, if there has been much suppuration of cornea, are the two forms usually observed after purulent ophthalmia.

As complications must be mentioned—Posterior synechiæ (following intrauterine iritis); persistence of portions of the pupillary membrane; atrophic changes in choroid and retina; displacement of the retina (particularly if the cataract has appeared rapidly, is large, of the uniform grey and opaque kind with chalky deposits on its surface, or if it appears as what is termed posterior polar cataract); opacities of the cornea (following intrauterine corneitis, or purulent ophthalmia); nystagmus (which generally appears soon after birth, if there be cataract in both eyes); coloboma; arrest of the development of the entire eyeball; absence of the iris; conical cornea; myopia. The latter is a frequent complication.

Symptoms and course.—The cataract, if well marked, is readily noticed by the parents soon after birth. When slight it is often overlooked. Patients may pass through life without its having been noticed, until it may have become complicated with senile cataract.

Nystagmus, smallness of the eyeballs, or some peculiarity in the movements of the eyes when objects are grasped, may attract the attention. If the cataract has been overlooked at first, it generally becomes noticed when the child begins to read: objects are held close to the eyes, or in a peculiar position.

The characteristic symptoms are opacities, varying in kind and extent, in and upon different parts of the crystalline lens or its capsule. The lens should be examined with artificial light, the pupil being dilated with atropia.

Numerous varieties arise from the varying forms and positions of the opacities. The most frequent are:—

(1.) A minute dot of chalky whiteness, situated in the middle of the clear pupil. The dot may have a conical shape projecting into the anterior chamber; or it may occupy the entire area of the pupil, the rest of the lens being transparent or slightly opaque. Small white dots may be found round the central one. A similar white opaque and circular dot is occasionally met with at the posterior pole of the lens.

(2.) Irregularly-shaped or circular faint grey and opaque or buff-coloured spots, of different sizes, which are sometimes extremely minute, very numerous, and sprinkled over the anterior surface of the lens (this form is often overlooked).

(3.) A ring-shaped, faint grey opacity at the posterior pole of the lens, with opaque striæ radiating from it.

(4.) An irregularly-shaped small opaque and white substance occupying the place of the lens.

(5.) A uniformly grey and opaque lens, or a semi-opaque nucleus with a transparent cortical substance.

The lens is generally smaller, and not unfrequently irregular in shape; the distance of its margin from the ciliary processes varies. Transparent portions of lens may intervene between opaque ones (so called lamellar cataract). The cataract, especially if of long standing, may be fluid (a thin layer of chalky white and opaque fluid enclosed within a tough capsule). Even in children (especially if iritis has preceded) a hard nucleus may be found.

The opaque white dots which are often seen in the area of the pupil are attached to that portion of the surface of the capsule which lies next the lens. They project through the pupil into the anterior chamber, and when touched with the needle often break off. In infants they generally appear grey and opaque. They gradually become whiter.

A preparation in the Museum of the Eye Infirmary, Moorfields, shows an irregular grey white and opaque substance occupying the place of the lens (during life it was pronounced to be a "deep-seated" opacity of the lens). Attached to it is a fibrous string, which, from the hyaloid fossa,

where it is firmly attached, passes backwards through the vitreous chamber to the surface of the retina (the region of the yellow spot) and to the optic disc, where it is firmly adherent. It enclosed numerous blood-vessels, none of which reached the hyaloid fossa. The retina could readily be lifted away from the choroid, by dragging the anterior expansion of the fibrous string ("the cataract").

For congenital cataract have been mistaken, (1.) Deposits in the vitreous chamber of a cancerous, strumous, &c. character.

We are assisted in the diagnosis of such deposits by the pupil being immovable; by there being no perception of light; by examination with the ophthalmoscope; and by the occurrence of such changes generally in one eye only.

(2.) Opacities in the cornea, adhesions of the pupil, and deposits of pigment in its area. In these cases, and also if the irregular, or otherwise contracted, pupil does not respond to atropia, supposing the patient to have normal perception of light, an iridectomy must precede any future treatment.

Treatment.

Any treatment tending to improve vision, or operations for the removal of cataract, should be adopted as early as possible. The sooner an operation is performed the quicker is the recovery, and the better the result as regards vision, movements of the eyeballs, &c. Cases of congenital cataract without perception of light, unless for reasons of personal appearance, should not be operated upon. The removal of the cataract from one eye, the fellow eye being sound, does not interfere with the functions of the sound eye. If there be perception of light, however slight, and even if the shape of the eyeball be below par, the cataract should be removed. Improved vision and nutrition of the eye operated upon will result.

Patients with an opacity confined to a circumscribed portion, e. g. the anterior pole, of the lens can with advantage, for years, make use of atropia. An iridectomy, without removing the cataract, may be recommended if the margin of the lens be transparent (which may be ascertained with the ophthalmoscope), the opacity well defined, and no increase of impaired vision complained of. By this treatment the accommodation of the eye is preserved; and the use of spectacles rendered unnecessary for years.

If neither the use of atropia nor an artificial pupil procures useful vision we remove the cataract, either by absorption, which is the slower and safer mode, or by linear extraction, or by suction. Children bear these operations well. The greater part of the cataract may, after opening its capsule, come to lie in the anterior chamber; and may become absorbed without

setting up much irritation, while the same accident in a grown-up person may lead to ophthalmitis.

Cases in which the bulk of the lens is transparent, and only the surface or some of the layers of the lens opaque, are more troublesome; more irritation accompanies absorption. When removing the irregular white and opaque substance, which in some cases occupies the place of the lens, we must be very careful not to use any force. If the substance should not readily follow traction with the forceps or sharp hook, it must either be left, or must be separated from adhesion, especially on the side next the vitreous chamber, by passing a small lancet-shaped knife behind it.

DISLOCATION OF THE CRYSTALLINE LENS.

("Ectopia of the Lens.")

(1.) *Dislocation of the Lens into the anterior chamber.*

The presence of the transparent lens in the anterior aqueous chamber betrays itself by a yellowish shining circular line (the margin of the lens), which, on looking sideways into the chamber, may be seen near the margin of the cornea. A similar appearance, though not so well marked, has in one case been caused by "vitreous" filling the chamber. The iris is pushed backwards, the pupil sluggish or fixed and somewhat dilated. The optic disc, viewed with the ophthalmoscope through the dislocated lens, appears unusually small.

The lens in this situation may remain transparent for years (in one case twenty years). It appears larger in its antero-posterior, and smaller in its lateral diameter; it gradually becomes yellowish. Attacks of iritis frequently follow, and the lens becomes adherent to the anterior surface of the iris. The posterior surface then loses its transparency, thus hiding the iris, the pupil, &c. After having undergone adhesions, the lens becomes smaller, and shrinks towards its adherent portion; while the pupil and the remainder of the iris become visible and tremulous. The dislocated lens may also become adherent to the posterior surface of the cornea, and cause ulceration and perforation which proceed from within outwards. The lens may become opaque and be absorbed, or it may change into a small chalky white hard substance. The latter sometimes rolls about freely, and passes from the anterior through the pupil into the posterior chamber. This substance may become adherent somewhere. Attacks of iritis, when once they appear, often recur.

The lens may be dislocated so as to stand sideways in the pupil, part of it projecting into the anterior chamber, where the peculiar golden reflection from its margin may be seen.

(2.) *Dislocation of the Lens into the vitreous chamber.*

A clear sluggish pupil, and a deep anterior chamber with tremulous iris, together with the history of the case, may lead us to suspect this dislocation.

The lens is generally visible to the unaided eye, and always when sought for with the ophthalmoscope. The observer should look with the ophthalmoscope as much as possible behind the lower posterior surface of the iris, while the patient directs the eyes downwards. The dislocated lens, which may be transparent, or greyish and opalescent, or chalky white, is readily perceived as a disc-shaped substance which floats behind the iris in the vitreous chamber. The entire lens is seldom visible; the well-defined opalescent margin farthest distant from the iris generally comes into view.

Sometimes the suspensory ligament is elongated, or only a portion of it is ruptured, and the lens is seen swinging to and fro behind the pupil. Cases have occurred in which the patient has had the power of displacing the lens through the pupil into the anterior chamber, and back again behind the iris.

The lens may be displaced directly backwards, together with the suspensory ligament, the latter having for some distance been stripped off the ciliary processes; or the lens, enclosed in its capsule, may have become detached from the hyaloid fossa, and fallen into the posterior chamber. In a case of this kind extraction of the lens has been performed with good result.

(3.) *Lateral or oblique dislocation of the Lens.*

The lens in some cases is found displaced towards the ciliary processes; in others one margin is tilted forwards towards the iris, while the opposite margin recedes towards the vitreous chamber. Part of the iris is pushed forwards, part of it recedes, as may be seen from the unequal depth of different portions of the anterior chamber. The iris is not always tremulous. Dislocation inwards and upwards is the most frequent form. The lateral displacement may be so considerable that only one third of the pupillary area is occupied by the lens; and when looking at the optic disc with the ophthalmoscope two optic discs are visible, one indistinctly, the other distinctly. When examining the inverted image we have to change the distance of the convex lens from the patient's eye, according to whether we view the optic disc through the patient's lens, or through the part of the pupillary area free from it.

In the Museum of the Eye Infirmary, Moorfields, is a preparation which shows a dislocation of the lens (by injury) between the ciliary processes and the sclerotic; other preparations show the above-mentioned varieties of dislocation.

If the dislocated lens leaves part of the pupil free, images of different degrees of distinctness are formed upon the retina, and diplopia or polyopia is complained of in the affected eye. Much light is reflected, and interferes with the distinctness of vision. Symptoms of astigmatism arise. A convex lens improves vision when held opposite the part of the pupil from which the crystalline lens is displaced.

The oblique position of a lens (one margin receding towards the vitreous chamber) can be recognized by the reflex images from its surfaces not standing opposite each other when the eye is directed straightforwards. The oblique position may be considerable without much lateral displacement.

Vision in dislocation of the lens into the anterior chamber is improved by concave lenses. Convex lenses should be tried when the crystalline lens has in part, or entirely, disappeared from the pupillary area. Patients with the lens swinging to and fro behind the pupil complain of objects moving, of an appearance as if flowing water were obscuring the object looked at, &c.

When once the absence of the lens from a part of or from the entire pupillary area, and the nature of the dislocation, have been ascertained, we must, in our further examination, be guided by the general rules in use in anomalies of refraction, accommodation, &c.

Every dislocation of the lens is complicated with more or less rupture of its suspensory ligament, and consequently with a loss, or a great impairment, of the faculty of having the curvature of its surfaces changed during accommodation.

(4.) *Dislocation of the Lens beneath the conjunctiva.*

The lens, if it has escaped through a rent in the tunics (which rent is generally found close to the upper margin of the cornea), may have done so completely; or its nucleus may have remained while the cortical substance has escaped; or the entire lens and capsule may have become lodged beneath the conjunctiva. The conjunctiva may appear vascular, or may remain transparent; in the latter case the displaced lens can be seen as a transparent or opaque disc-shaped little tumour, sometimes hiding the rent in the coats of the eyeball. The iris is not always tremulous; frequently a portion of it is drawn into the rent, the pupil being distorted or displaced towards it. For two or three months the lens may remain beneath the conjunctiva, and give no trouble; or it may become opaque and absorbed, leaving its capsule sprinkled with particles of chalk.

Causes.

Most of the above forms of dislocation may be produced by injury (frequently by a blow upon the lower part of the eyeball). Looseness or

rupture of the suspensory ligament, or changes in the consistence of the "vitreous," favour dislocation by injury. Dislocation occurs often spontaneously in both eyes; and sometimes in several generations, or in several members of one family. It is often congenital. Most frequently it becomes troublesome after middle age. A fluid condition of the "vitreous," shrinking of the lens itself, a looseness of the suspensory ligament, a general enlargement of the eyeball, may give rise to it without any other changes being visible in the tunics of the eyeball. Myopia is not an unfrequent complication.

The shape of a dislocated lens is often altered; it is indentated or flattened in some parts of its margin.

Complications.—Among the complications arising from injury the most frequent are:—rupture of the tunics of the eyeball,—laceration of the iris,—hæmorrhage into the interior of the eyeball,—escape of vitreous,—displacement of the retina. The complications to which the displaced lens gives rise are iritis, choroiditis, and glaucoma.

The lens sometimes undergoes adhesion to the iris, hyaloid membrane, &c., during an attack of inflammation, after which all further disturbance may cease. Attacks of inflammation are often accompanied by great pain. Sudden attacks of pain may occur (the lens being displaced into the vitreous chamber) during certain positions of the patient, e. g. during the recumbent position.

Glaucomatous symptoms frequently appear, whether the dislocated lens be fixed or move about, whether the eye suffer from inflammatory attacks or not. Sympathetic affections of the fellow eye are not unfrequent.

Treatment.

The Lens being dislocated into the anterior chamber.

We need not interfere if the lens is transparent, if the eye is free from irritation, if the fellow eye does not sympathize, and if vision is such as to allow the patient to follow his occupation.

The lens should be extracted if opaque or chalky, and if the patient is anxious to have it removed, though the eye be blind. The lens ought to be removed (by absorption, by linear extraction, or by suction) if it is opaque and the retina sensitive. If iritis or glaucomatous symptoms should arise iridectomy is performed as well as extraction.

These operations in some cases have been followed by slow displacement of the retina (in otherwise large myopic eyes), in others by shrinking of the eyeball, in a few by ophthalmitis.

If the lens is dislocated into the vitreous chamber it does not become absorbed, though it be lacerated.

In some cases it has been extracted successfully with the scoop through an incision in the cornea. In a few instances the operation has been followed by shrinking of the eye.

The lens should, if possible, be removed by absorption, combined with iridectomy, if it is *displaced laterally or obliquely,* and if iritis, or sympathetic irritation, or glaucomatous symptoms arise, or if vision is too much impaired. If there be no such complication, and vision is sufficiently good for the occupation of the patient, nothing need be done. If myopia exist, concave lenses may be of use. If the greater part of the pupillary area is free from the lens, convex lenses may be tried. If the lateral dislocation is but slight, an iridectomy on the side towards which the lens is displaced can be recommended: and spectacles are thus rendered unnecessary.

Traumatic Cataract.

A lens, if otherwise healthy, can bear considerable injury without losing its transparency, especially if its capsule has not been extensively ruptured.

A clean small incision into the capsule may either heal at once, or does so after absorption of some opaque protruding lens substance; or it may heal with a circumscribed opacity. Generally, however, the wound in the capsule becomes widened through swelling of opaque and protruding lens particles. The larger the wound is the more of the lens becomes exposed, and the quicker does cataract appear. The older the lens is the more rapidly does it become opaque, and the more likely is the injury to cause inflammation. The lens may become opaque through concussion of the eyeball, without any of the tunics of the eye having been perforated. It may become opaque, adherent to the cornea, and absorbed, if the aqueous humour has escaped at the time of injury. Portions of the lens may escape through the wound; the capsule may become adherent to the cicatrix; and the rest of the lens may remain transparent. Or the lens, pressing against the cornea, may give rise to corneitis, or to staphylomatous condition of the cornea. A foreign body, e. g. a piece of iron, entering the eye and causing cataract, may remain lodged in the cataract.

We must suspect a foreign body to have passed into or through the cataract if after an injury we observe reddish or brown pigment spots upon or among the opaque lens matter. An opaque line, in an otherwise transparent lens, may help to indicate the course taken by the foreign body. The latter, in recent cases, may be seen lodged in the lens. If deep-seated, it may, by passing a needle behind it, be pushed near the anterior surface of the lens, and removed by the scoop.

Foreign bodies not unfrequently pass into the eye through the sclerotic, or just at the margin of the cornea, without wounding the lens; or they may

pass through the latter near its margin, leaving a circumscribed cicatrix, and become lodged in the vitreous chamber, choroid, &c. The foreign substance, usually a piece of steel, or iron, or glass, can frequently be seen as a shining, brilliant, defined, somewhat moveable substance suspended in the vitreous chamber. Its nature, whether iron, &c., has been recognized in some cases by the application of a magnet to the cornea or sclerotic. If the foreign body is level with the retinal vessels, it can be seen at the same time with them by the ophthalmoscope.

A clot of blood often surrounds the foreign body if situated in the choroid. The blood having disappeared, the body can, with the ophthalmoscope, be seen surrounded by atrophic portions of choroid.

Small pieces of glass, steel, or iron have been known to remain in the eye for ten years or more, setting up but slight occasional irritation, or remaining altogether unobserved. This is the case more particularly if the foreign body is some inorganic substance, and becomes lodged in a part which is not actively engaged during vision, e. g. in the part of the vitreous chamber which lies within the area of the retina, or in the anterior chamber, &c. A small shot situated between the margin of the lens and the ciliary processes close behind the suspensory ligament gave rise in one case to glaucomatous symptoms, and to much sympathetic irritation.

It often happens that the foreign substance changes place, comes in contact with vascular parts of the eye, and gives rise to attacks of inflammation. For instance, it may, having remained lodged in the crystalline lens, fall into one of the aqueous chambers after the cataract has become absorbed; or, situated in the vitreous chamber, it may from its weight sink to the bottom of the chamber, and come into contact with the choroid or retina. The rule is that, if the foreign body has passed into the eye, and is left there, the sight of the eye sooner or later becomes destroyed, either by glaucoma, or more often by repeated attacks of choroido-iritis, or through acute ophthalmitis. In rare cases the shape of the eye remains intact, and the foreign substance becomes enclosed in a capsule of dense opaque fibrous tissue, or of bone.

We should in every case of injury in which we suspect a foreign substance to be lodged within the eye, carefully examine the interior of the eye by lateral illumination, and with the ophthalmoscope.

The lens, if opaque, should be removed at once. The operation of iridectomy should be performed at the same time.

If the lens is transparent, and the view of the deeper parts is obscured by blood in the vitreous chamber, we may be almost certain that a foreign body is in the eye, especially if a few days after the injury chemosis appears with iritis, and if attacks of iritis recur. In such cases we keep both eyes at rest, the injured one bound up and under the influence of atropia, and see whether chemosis and iritis follow. These symptoms, as a

rule, appear within from twelve to thirty-six hours after the injury, if the foreign body is still in the eye. A yellowish reflection from behind the pupil (supposing the lens to be transparent) indicates pus in the vitreous chamber. The eye, as regards vision, is lost when once pus appears in the vitreous chamber, even if we succeed in extracting the foreign body. The latter, as a rule, occupies the part of the vitreous chamber in which the opacities are most dense, and the yellowish reflection most distinct. The injured eye in this stage, if there is sympathy of the fellow eye, should be at once excised if we have not succeeded in removing the foreign body.

If no pus appear in the vitreous, and the iritis be but slight, we keep the eye under the influence of atropia, and closed until all inflammation has ceased. The eye may be left alone if we perceive behind the lens a foreign substance which, however, does not make itself felt to the patient. The patient must be told that, if the eye becomes inflamed, or the fellow eye weak, he should seek advice at once. Excision of the eye has to be performed if inflammation sets in, and we do not succeed in removing the foreign body.

If we cannot discover any foreign substance in the eye, and if iritis appears, we keep the eye at rest, closed, and under the influence of atropia, unless its tension becomes increased, when iridectomy should be performed. Both eyes must afterwards be kept at rest, and the injured eye closed until all inflammation has ceased.

(See also Injuries of the Iris, Choroid, Vitreous Substance, &c.)

Vision.

Patients with simple traumatic cataract generally state that the sight of the injured eye has become misty after the injury, not suddenly, but gradually.

Hæmorrhage into the vitreous chamber, displacement of retina, rupture of the choroid and glaucoma, are the more frequent complications of traumatic cataract. The surgeon, who is familiar with the symptoms peculiar to each of these complications, will generally succeed in distinguishing the changes as regards vision which are due to the cataract from those which depend on other morbid conditions.

Patients when under treatment (by absorption) must be carefully watched as regards the power of perceiving light and the tension of the eyeball. Destruction of the optic nerve fibres by glaucoma during absorption of cataract has often been observed.

The cataract may become completely absorbed, and the eye appear healthy, and yet there may remain no useful vision or but little. Among the out-patients of Guy's Hospital, a case occurred about twelve months ago, in which a blow from a fist was followed by sudden complete loss of sight. For about four months no change occurred. The lens was partly

dislocated, and the parts behind it could not be illuminated. There was no pain and no increase of tension. About five months later the patient was able with the injured eye to recognize the features of persons. On examination with the ophthalmoscope, the lens was found partially dislocated (its upper margin tilted backwards); numerous opacities in the vitreous chamber, a large rent in the choroid, and some atrophy and anæmia of the optic disc, were also met with.

Displaced retina either appears at the time of injury, with or without hæmorrhage into the vitreous chamber; or, as is more frequently the case, shows itself at a later period, especially in cases in which the lens has been dislocated and removed. (See Displacement of Retina.)

Chronic choroido-iritis, with increased tension, causing impairment of vision, has been observed to follow, not only during the absorption of traumatic cataract, but also a considerable time after the removal of cataract.

Treatment.

Simple traumatic cataract in persons below middle age may be left for absorption; or may be removed by linear extraction, the pupil being kept well dilated by atropia. In persons above middle age we remove the cataract by extraction. At all ages, if there is much iritis, or the iris is pressed forwards upon the cornea, or the tension of the eyeball too great, iridectomy is performed; and the cataract, according to its consistence and the age of the patient, removed either by suction or by extraction. The same treatment is adopted if considerable time has elapsed since the injury, and part of the cataract has become absorbed, but absorption from some cause been arrested.

CHAPTER IX.

THE AQUEOUS HUMOUR AND THE AQUEOUS CHAMBERS, AND THE VITREOUS SUBSTANCE AND THE VITREOUS CHAMBER.

The aqueous humour ("the aqueous") chemically consists of transparent fluid, with traces of salt (chloride of sodium) in solution. Mixed with it we may find albumen (e. g. in cases of iritis); fibrin and blood corpuscles (from spontaneous rupture of blood-vessels, or from injury); or merely the colouring matter of blood; sugar (in diabetes); bile; or pus (in inflammation of the surrounding tunics).

Hypopyon signifies an accumulation of pus in the aqueous chamber. The pus may come from an abscess of the cornea perforating into the chamber, or from transudation of plastic material from an inflamed cornea, iris, &c. In the purulent fluid we find mucus, pus-cells, granules, and fat molecules.

An unusual quantity of aqueous humour, or its complete absence, or the presence of blood or pus occupying its place, has been observed at birth.

The anterior chamber in most persons of advanced age becomes smaller, from decrease of the quantity of aqueous humour.

The blood-vessels of the iris, and especially those of the ciliary processes, are supposed to be the chief source of the aqueous humour. This view is supported by the facts that little aqueous humour is found when most of the vessels of the ciliary processes and of the iris have become obliterated by inflammation, and that, if the pupil appears completely closed and the tissue of the iris tolerably healthy, aqueous fluid is found in the anterior chamber.

In total posterior synechia we may find the iris bulged forwards by accumulation of fluid behind it, or between its uveal and contractile portions.

An increase in the quantity of aqueous humour is observed after a

successful iridectomy, performed for diminution of increased tension of the eyeball.

Escape of the aqueous humour, especially if it occurs suddenly, causes contraction of the pupil, with sudden enlargement of the blood-vessels of the choroid and retina. A prolonged escape through a fistula in the cornea may lead to gradual shrinking of the eye.

Twelve hours is supposed to be the time necessary for the secretion of the usual quantity of aqueous humour of a healthy eye. After operations on the iris we often find the anterior chamber filled with aqueous humour half an hour after all has escaped.

Changes in colour of the aqueous humour disguise the real colour of the iris, e. g. a blue iris appears greenish or yellowish when viewed through even a slight mixture of hæmatine with aqueous fluid (" yellowish aqueous humour ").

Blood in the aqueous chamber becomes quickly absorbed (in from twelve to thirty-six hours) if the eye is healthy; while, if under the influence of inflammatory changes, months may pass before all blood has disappeared. The effused blood itself sometimes sets up irritation. Artificial pressure should be applied to hasten the absorption of blood in a diseased eye; while blood effused into the chambers of a healthy eye may be left to itself.

Pus generally disappears rapidly from the anterior chamber. The heavier particles of pus, blood, &c., settle at the most dependent part, and appear along the lower margin of the cornea as a well-defined crescentic yellow or dark red substance. Movements of the head or eye cause this substance to change its position; or, when stirred up, to mix with the fluid in the aqueous chamber.

Particles of cataract, of lymph, of blood, &c., frequently leave spots of pigment, or of earthy salts, upon the walls of the chambers.

A cysticercus, moving about in the aqueous humour, has been removed by paracentesis.

Cilia and particles of glass have remained free in the anterior chamber for ten years without causing irritation.

A case is reported in which vision was lost by bleeding between the choroid and retina, after a leech-bite in the lower half of the cornea. The chambers were filled with blood.

The boundaries of *the anterior aqueous chamber* are:—in front, the epithelial covering of the posterior elastic lamina of the cornea; laterally, those portions of that lamina which pass on to the iris; behind, the epithelial covering of the anterior surface of the iris, and the capsule of the crystalline lens as far as it occupies the area of the pupil.

The remainder of the anterior capsule of the lens, together with the anterior surface of the suspensory ligament (part of the canal of Petit),

form the posterior boundary of the posterior aqueous chamber; the tips of the ciliary processes, the lateral boundary; and the transparent membrane covering the uvea, the anterior. The pupil is the opening of communication between the anterior and posterior aqueous chambers.

The aqueous humour probably passes between the margin of the pupil and the surface of the capsule of the crystalline lens, from one chamber into the other. The size of the chamber is determined by the position of the crystalline lens, of the iris, and of the posterior surface of the cornea.

In a *deep* anterior chamber (where the distance of the iris from the cornea is unusually great) the margin of the pupil and the insertion of the iris may be in the same plane; while in a *shallow* anterior chamber the pupil lies much in advance of the insertion of the iris.

Adhesions of the pupillary margin may cause an accumulation of aqueous fluid behind the iris, or between its uveal and contractile portion; and by bulging these may give rise to a shallow anterior chamber, with retraction of the margin of the pupil.

A small puncture of the bulging portion causes the fluid to pass into the anterior chamber, and the bulged portion of iris to assume a more normal position. On the other hand (e.g. after extraction of cataract) the margin of the pupil may become adherent to a portion of the capsule of the crystalline lens, and appear pushed back towards the vitreous chamber, thus increasing the depth of the anterior chamber. Changes in the depth of the anterior chamber are observed in chronic glaucoma, presbyopia (diminished depth), inflammatory changes of the choroid and iris during fœtal life or in infancy (increased depth).

THE VITREOUS SUBSTANCE AND THE VITREOUS CHAMBER.

ANATOMICAL AND GENERAL REMARKS.

The vitreous substance (vitreous humour, vitreous body, "vitreous") occupies the vitreous chamber. The "vitreous" slightly exceeds, in consistence and cohesion, that of the white of a hen's egg. It is transparent, and some of its elements possess great elasticity.

Placed on blotting-paper the watery portion becomes absorbed, and a delicate tissue, consisting of nucleated fibres, remains.

Replaced in water, this tissue swells out again, and resumes almost its former appearance.

Continued pressure, whether from external or from intra-ocular causes,

tumours, &c., rapidly cause the fluid part to disappear. Traces of albumen are found in the healthy vitreous.

The vitreous microscopically consists of transparent fluid, and of numerous transparent fibres enclosing cells. These cells and fibres are more numerous at and near the surface of the hyaloid membrane (see Plate I., Figs. 3, 4), especially where this membrane passes over the ciliary processes. Upon the inner surface of the hyaloid membrane is found a single continuous layer of large cells. Each cell has one large transparent nucleus. These cells are smaller on the portion of the hyaloid membrane which joins the suspensory ligament of the lens.

The "vitreous" is separated from the surrounding tunics by the hyaloid membrane. The outer surface of the latter is slightly adherent to the retina, and more firmly to the part of the optic disc from which the retinal vessels emerge, and to the suspensory ligament.

The suspensory ligament of the lens ("the Zonula Zinnii" or "the pars ciliaris retinæ." See also Crystalline Lens—Anatomical Remarks) is a transparent membrane. Some describe it as a continuation of the retina. It is intimately connected with the retina, covers the ciliary processes, and is placed between these and the hyaloid membrane.

An amorphous portion passes over the posterior surface of the iris, and merges into its elastic lamina; while the fibrous portion, which lies next the hyaloid membrane, leaves the ciliary processes near their apices to join the anterior part of the capsule of the lens.

For the method of examining the vitreous, see Opacities in the Vitreous Chamber.

Senile Changes.—The transparent cells of the vitreous substance appear less numerous as age advances; while the "opacities," especially those close behind the lens, increase in extent. The central portions of the "vitreous" become more fluid; while the hyaloid membrane becomes thickened, and more so in some parts.

The transparency of the "vitreous" becomes altered. The vitreous assumes a more or less yellowish tint.

DEVELOPMENT.

The vitreous substance at the end of the second month appears as a transparent membrane placed between the large lens and the retina. This membrane, termed the hyaloid membrane, is thicker than the capsule of the lens, and is folded. The folds adapt themselves to those which are seen in the retina at about the same period. Such folds of retina and hyaloid membrane may persist until after birth.

At the middle of the third month additional membranes are observed within the hyaloid membrane. The vitreous substance during the fourth

month already occupies twice as much space as the crystalline lens. It varies in colour, being nearly transparent and red, changing into a yellowish, then into a greenish colour, and finally becoming colourless and transparent.

An indentation observed along the most depending part of the hyaloid membrane at a later period changes into a canal termed *the central canal.*

A raphé remains at the point of union of the walls of the indentation and joins the remnants of the fœtal fissure in the retina. If the raphé is visible after birth it is the result of morbid changes, or of anomaly in development.

A vertical section made about the second month through the vitreous substance at the equator presents on the surface somewhat the shape of a horse-shoe. A section made about the third month at the same spot presents a more crescentic shape. As soon as the points of the crescent have met, *the central canal* is completed. This canal extends across the vitreous chamber from the lower margin of the optic disc to the corresponding margin of the hyaloid fossa. Within it runs an artery (*the arteria centralis*).

The canal runs near the surface of the retina if the original sulcus (or the indentation in the hyaloid membrane) has been slight; but if the sulcus has been considerable, the canal may pass through the middle of the vitreous chamber. It closely surrounds the central artery.

About the middle of the fifth month we find the central artery extending from the optic disc to the hyaloid fossa. At first it is very tortuous, probably for the purpose of adapting itself to the growth of the vitreous substance.

At the optic disc it sends small branches into the sclerotic and choroid, larger ones into the retina, and numerous ones into the vitreous chamber. The latter branches disappear about the end of the ninth month.

The vitreous substance participates in the changes which the shape of the eye undergoes during development.

About the commencement of the fourth month it is somewhat pyramidal, the lens resting on the base of the pyramid, the apex being directed downwards and backwards towards the fœtal fissure.

During the first month the smooth hyaloid membrane is in close contact with the margin of the lens.

At the commencement of the fourth month the ciliary processes and the canal of Petit appear, and the hyaloid membrane adapts itself to the surfaces of the ciliary processes.

On minute examination at the commencement of the second month we find upon the inner surface of the hyaloid membrane slightly projecting transparent lines, which are placed at certain distances from each other, and converge towards an anterior and a posterior pole.

At the commencement of the third month we find the yellowish transparent gelatinous vitreous composed of a network of cells with fibres (tubes?). The latter are connected with each other by delicate transparent membranes. The spaces between these are filled with transparent fluid.

About the fifth month these cells and fibres can be readily recognized. They are most numerous at, or near, the hyaloid membrane, as also in the vitreous substance which lies within the area of the ciliary processes. These, together with the central canal, may be seen in a preparation in the Museum of the Eye Infirmary, Moorfields. The cells and fibres in that specimen radiate from the central canal, into the walls of which they are inserted; the hyaloid membrane is their second surface of insertion.

CONGENITAL ANOMALIES.

Besides the anomalies described under "Coloboma," we often observe a slender brilliant white and opaque thread-like projection from the optic disc (at the side nearest the yellow spot) tapering off into the vitreous chamber. This in one instance reached as far as the outer and lower part of the hyaloid fossa, causing an appearance of what might have been termed congenital cataract.

The red colour of the vitreous substance, observed during the third month, has been met with after birth.

Absence of the vitreous substance with displacement of the retina and "fluid vitreous" are attributed to intrauterine choroido-retinitis.

Anomalies in Consistence.

The anomalies in consistence which have been observed are—(*a.*) The too firm; (*b.*) The nearly fluid; and (*c.*) The fluid vitreous substance.

(*a.*) *The too firm* yellowish and transparent vitreous substance is, compared with healthy vitreous, hard to the touch. In some instances it approaches the consistence of soft cartilage. It is frequently found in the glaucomatous eye.

(*b.*) *The nearly fluid* vitreous substance has been found in glaucomatous eyes, the tension of which at the time has been below par; in eyes in which, after profuse hæmorrhage, the vitreous substance has been broken up; and in others in which, through atrophy of the choroid, the nutrition of the vitreous substance has suffered.

(*c.*) *The fluid* vitreous substance (*Synchysis*). This change may occur in any portion of the vitreous, but is most frequently found in that part which lies within the area of the retina. The fluidity may be confined to the surface, or may occupy the centre, or only circumscribed portions, e. g. those contiguous with atrophic portions of retina and choroid.

The partial, or general fluidity, especially if it appears with inflammatory changes of the adjoining tunics, is often complicated with loss of transparency of the solid parts of the vitreous substance. Grey opaque or silvery white points, membranes, shreds, or filaments, &c., appear, which freely float, and gravitate in the fluid portions.

Fluid vitreous substance with or without opacities has been observed in eyes with normal vision. It has been found in eyes suffering from senile (atrophic) changes, and again in eyes generally enlarged.

The fluidity cannot be recognized unless associated with dislocation of the lens (the latter floating freely in the vitreous chamber) or with floating opacities. Even in such a case only the portion in which the lens floats may be fluid, while the rest retains the normal consistence.

For alterations in consistence of the vitreous substance, see also Ophthalmitis, Sympathetic Iritis, and Tumours within the Orbit.

Tremulous iris has been observed in eyes in which the vitreous substance in the area of the retina alone has been fluid; while the lens, with normal vitreous next it, and the iris have seemed to move under the impulse of the fluid vitreous. (See also Iridodonesis.)

The term *Sparkling Synchysis*, or *Synchysis Scintillans*, is applied to a more or less fluid condition of the vitreous substance with *cholesterine crystals* suspended and floating, or gravitating, in it.

The crystals can be seen (by the naked eye, with focal illumination, and with the ophthalmoscope) as minute brilliant silvery white scales floating in the vitreous chamber. They appear in the course of changes following inflammation of the tunics. They have been found in the lens, in all the tunics, in the chambers, and in the fluid between the choroid and retina. Sometimes they appear suddenly, like hæmorrhage, and are preceded by general symptoms, such as pain in the eyes, headache, &c., pain in the hepatic region, &c. These symptoms subside with the appearance of the crystals in the eye. The crystals disappear spontaneously, and sometimes within a few days.

This may be followed by, or be complicated with, displacement of part of the retina.

Opacities in the Vitreous Chamber and Muscæ volitantes. Motes.

The nutrition of the vitreous substance is intimately connected with that of the retina and choroid, and we hardly ever fail to discover morbid changes in the vitreous if the adjoining tunics are in a state of inflammation. These changes result in what are generally termed opacities, the loss of transparency being the most striking symptom of morbid alterations of the vitreous substance.

The nucleated fibres and membranes of the healthy vitreous substance

become visible under peculiar circumstances, and represent what are termed *Muscæ* or *Motes*.

Suppuration, and other, especially syphilitic, forms of inflammation, and absorption of the fluid part of the vitreous substance, give rise to *opacities*. Opacities as a rule appear round tumours and foreign bodies, wherever in the vitreous chamber these may be seated. The opacities are most numerous *immediately* round the tumours, &c.

Opacities are usual complications of inflammation of the choroid, especially of the ciliary processes. They appear as yellowish and opaque floating membranes, &c., if the choroiditis be of suppurative character; grey and opaque if it be more of the plastic kind. They are readily seen by the observer, but not by the patient, to whom they produce the sensation of a mist intervening between the eye and objects.

Hæmorrhage into the vitreous chamber, foreign bodies in it, entozoa, tumours, distension of the vitreous chamber during staphylomatous changes, and the different forms of retinitis, are other causes of opacities.

Vision is impaired according to the density, size, and situation of the opacities.

Those near the retina throw a shadow, and more or less intercept the light. Such, as regards shape, are accurately described by the patient if the retina is sensitive.

Opacities close behind the lens and in the middle part of the vitreous chamber give rise to general "mistiness" of vision, and to absorption of some, and to diffusion of much, of the light which passes through the vitreous chamber.

During reading the opacities may intervene between the retina and the letters looked at. The patients, by rapid movements of the eyes, cause the opacities to move away from opposite the parts of retina used in reading. The repetition of this movement finally becomes a habit frequently met with in persons suffering from opacities.

The mobility of the opacities is the greater the nearer they are to the middle of the vitreous chamber; the density and number are the greater the nearer they are to the hyaloid membrane.

Opacities of great mobility are less dangerous to the nutrition of the eye, and to the functions of the retina, than those of a more fixed character.

The latter, while shrinking, may lead to displacement of the retina, or to alteration in shape, or even to shrinking of the eyeball.

The moveable ones, though they rarely disappear completely, often become less perceptible under proper treatment.

Muscæ (*Muscæ volitantes, Motes*).

Muscæ are structures suspended in the vitreous chamber, and are de-

scribed by patients as transparent or slightly yellowish, or translucent little circles with clear centres, or as filaments or granules, or strings of globules of varying number, twisting about and floating at a certain distance in front of the eyes.

A quick movement of the eyes, e. g. upwards, causes them to fly upwards; then, as the eyes are steadied, they slowly sink back towards the spot from which they started. Through sudden arrest of such movements the filaments and strings of globules become twisted and curled up, after which they again alter in shape, and return to their former positions. Looking at print, at microscopic objects, &c., part of the object is obscured by them if they are numerous or semiopaque; and a rapid movement of the eyes is necessary to remove them for a time from the field of direct vision.

They generally at first appear rather suddenly, and for several years increase in number.

They are, as a rule, observed in slightly myopic persons.

Examination.—Muscæ, though readily seen by the patient, and well described as regards size, colour, shape, &c., are not visible to the observer unless the vitreous substance be examined microscopically. Muscæ thus differ from "Opacities;" the latter are more often visible to the observer than to the patient.

"Opacities," when situated close behind the lens, can sometimes be seen with the naked eye, and always with lateral illumination, or with the ophthalmoscope. Those in the deeper parts of the vitreous chamber, when viewed with the ophthalmoscope "indirectly," appear as dark opaque shreds, membranes, &c., floating in front of a bright red background. They intercept the light which returns from the sclerotic and choroid. To see their real colour, shape, position, and amount of mobility, they should be examined directly with the ophthalmoscope. They are generally white or grey-white, or yellowish and opaque.

Varieties of colour may arise from the presence of blood and cholesterine crystals.

The patient, during the ophthalmoscopic examination, should look rapidly in different directions, so as to bring into view all parts of the vitreous chamber, and to impart movement to particles which may be floating in it.

Muscæ, their distance from the retina, and their mobility, can readily be ascertained by *entoptic examination.*

Opacities situated close in front of the retina, throw shadows, and can be seen. Those farther distant from the retina may be rendered visible by looking towards the bright sky through an opening (about ·00393 in. wide) in a thin black metal blade, holding the opening at about ·51182 from the eye. Opacities which lie within the area of the circle of light received by the retina, are then distinctly seen.

The little circles and strings of globules situated at from ·03937 to ·15748 in. from the retina are as a rule seen without looking through the small opening; while numerous membranes, observed in the vitreous of every healthy eye close behind the crystalline lens, can only be made visible by entoptic examination. (See also Examination of the Crystalline Lens.)

Treatment of Muscæ.

If we cannot perceive the "muscæ" with the ophthalmoscope, we may assure the patient that no fear as to loss or serious impairment of vision need be entertained.

No kind of treatment can remove them completely: their apparent number however may be reduced so as to render them hardly perceptible, if the patient takes much out-door exercise, abstains from close work, especially at night, and avoids whatever may be weakening.

The muscæ are often lost sight of (especially in myopic persons) when the eyes are under the influence of atropia. Some prefer the inconvenience arising from the atropia to the anxiety caused by the muscæ. Spectacles with tinted glasses (attention being paid, if necessary, to any anomaly of refraction that may exist simultaneously) should be recommended if the muscæ are very troublesome.

Treatment of Opacities.

See treatment of hæmorrhage into the vitreous chamber; of suppuration of the vitreous substance; of choroiditis. The different forms of choroiditis are frequently complicated by inflammatory changes in the vitreous substance of a similar character to those in the choroid.

INJURIES OF THE VITREOUS SUBSTANCE.

An injury of the vitreous substance may be followed by suppuration (see Pus in the Vitreous Chamber and Ophthalmitis) or by an escape of blood into the vitreous chamber (see Hæmorrhage into the Vitreous Chamber). It is generally complicated with injury of adjoining tunics (see Traumatic Cataract and Injuries of the Tunics).

Incisions into the vitreous substance, such as are made when operating upon displaced retina,—when tearing up opacities in the vitreous chamber, when removing portions of that substance protruding from wounds,—or by accidental wounds, are rarely followed by formation of pus, or by inflammation, provided they are made with clean instruments, and do not give rise to suppuration of adjoining parts.

Prolapse of " vitreous " and loss of " vitreous."—Much vitreous may be lost without finally impairing vision. (See Extraction of Cataract.)

CYSTICERCUS (C. TELÆ CELLULOSÆ) IN THE DEEPER PARTS OF THE EYE.

The cysticercus has been observed in all parts of the eye. The ages of the patients have varied between twenty and sixty. The greater number were from twenty to thirty years of age. Some of these had suffered from worms in childhood (Oxyuris and Ascarides), others from Tænia (lata ?) for some time previous to the eye having become affected. In several cases no worms could be traced. The cysticercus has been found in the vitreous chamber, and in, upon, and beneath the retina.

Vision may be lost within a fortnight after the appearance of the entozoon. For a varying period this may be preceded by impairment of vision confined to certain parts of the retina, so that e. g. objects can be perceived better in some directions than in others; or a mist, which gradually becomes thicker, may appear to intervene between the affected eye and objects.

Flashes of light, fiery circles, &c., were complained of by some of the patients in whom the entozoa were visible beneath the retina. In several cases the appearance of the entozoon was preceded (for years) by severe headache.

The cysticercus, when in the vitreous chamber, appears as a bluish-grey vesicle, occupying some part of the chamber. It has a limited undulating movement of its own (contraction and dilatation), which is independent of the movements of the eye.

This vesicle (by a circular indentation in some part of it) is separated into a larger portion (the body), and a smaller one (the head), which latter, when protruding, brings into view the long thin neck.

In older cases one or several vesicles were visible near the cysticercus. In one case the hooklets (one being in the middle and two at the sides) could be distinguished.

Fine, peculiarly continuous, greyish-opaque membranes ("opacities") are found round the cysticercus soon after its appearance in the vitreous chamber. These increase during its growth.

Only in a few cases have these opacities been missing. In such cases the entozoa were seen changing their places in the vitreous chambers.

In one case an attempt was made to extract the cysticercus, which failed, but killed the animal. In another it was extracted through the cornea (an iridectomy having preceded this operation), after which the vitreous nearly resumed its transparency, with considerable improvement

of vision. In another case many of the membranes in the vitreous chamber disappeared after iridectomy.

Iridectomy, followed by extraction of the entozoon, should be tried in all cases in which the entozoon is distinctly visible and only surrounded by semitransparent opacities, especially as long as some vision is likely to be saved. The incision for its removal is made through the equatorial part of the sclerotic if all vision is lost.

The cysticercus, when appearing in the retina (in and beneath which it has primarily been observed), always gives rise to displacement of that membrane. It may thus be easily overlooked. When it is situated beneath the displaced retina we find, on careful examination with the ophthalmoscope, that in addition to the floating displaced retina with its blood-vessels, a sharply-defined line is visible beneath some part of the retina. On tracing the continuation of this line it can be recognized as the outline of a vesicle (the body of the cysticercus being about four times as large as the optic disc). The choroid near the entozoon assumes a grey or yellowish-opaque colour.

Sometimes the undulating movements of the entozoon can be recognized; these are independent of the movements of the displaced retina. A white dot on one part of the vesicle represents the head. The latter, with the neck, seemed in one case to move to and fro in a kind of tube, formed by membranous "opacities."

The cysticercus generally perforates the retina. In several cases a greenish or yellow and opaque line in the retina (at some distance from the entozoon) has seemed to have been the spot through which it has passed into the vitreous chamber.

In one case a kind of capsule had formed round the cysticercus, after which it remained stationary, not giving rise to further inflammatory symptoms.

Choroido-iritis, yellowish aqueous humour with sluggish pupil, discoloured iris, and a yellow metallic reflection from behind the pupil, have occurred as frequent complications. Within from six months to two years shrinking of the eyeball follows.

Entozoa have not yet been observed in both eyes of the same person.

HÆMORRHAGE (EFFUSION OF BLOOD) INTO THE VITREOUS CHAMBER.

Blood, when penetrating into the vitreous substance, breaks up the latter and remains almost fixed in its position, until secondary changes and the movements of the eye lead to its becoming more mobile.

The opacities, as observed with the ophthalmoscope after hæmorrhage,

are partly caused by blood, partly by displacement of the elements of the vitreous substance (see Plate II., Fig. 2), and by subsequent chemical changes of the latter, and of the blood.

Larger clots gradually separate into smaller ones. Their red colour may have disappeared in from three to six weeks.

In rare cases the vitreous substance becomes transparent again, e.g. we may find it mixed with brown red clots some weeks after an injury, and two months later all trace of opacity may have disappeared spontaneously. Generally opaque shreds and membranes remain for years, with a varying amount of mobility. In some instances, however, especially if close behind the lens, the clots retain their bright red colour for months.

Hæmorrhage occurs most frequently in that part of the vitreous which lies within the area of the ciliary processes. The blood may escape from the vessels of the ciliary processes and perforate the suspensory ligament; more often, however, it comes from the vessels of the retina along the ora serrata.

Suppuration of the eyeball or of some of its parts may follow hæmorrhage from injury, especially in aged persons, and vision thus become destroyed. If suppuration follows, it does so, as a rule, one or several days after the injury. It need not be expected if a week or more have elapsed since the injury.

In enumerating *the causes* of hæmorrhage we should but have to repeat what has been said under "Hæmorrhage into the Retina." Be it stated in brief that among intra-ocular causes the most common are those which give rise to increase of tension of the eyeball, and those which are complicated with atrophy of the choroid. Of general causes may be mentioned as most frequent:—anomalies of menstruation, causing hyperæmia of the choroid and retina, and diseases of the heart and arteries.

Clots of blood immediately behind the lens are readily seen by focal illumination. Those in the deeper parts by the ophthalmoscope. To see their real colour and position they should be examined with the ophthalmoscope "directly." The patient should turn the eye in different directions, so as to ascertain the mobility of the clots.

Vision.—The mode of impairment of vision in patients who have had useful sight previous to the hæmorrhage, varies according to the part of the vitreous chamber occupied by the blood,—according to its quantity and rapidity of appearance,—and according to the changes which the blood and surrounding vitreous substance and other structures may have undergone.

A sensation, as if some "grit had got between the eyelids," with a dark shadow, or a red-coloured cloud, appearing suddenly in front of the affected eye, are often complained of by the patient if the hæmorrhage has occurred near the retina, and especially near the region of the yellow spot. The

nearer the latter the better does the patient describe the impairment of vision.

Hæmorrhage into the equatorial region of the vitreous chamber, or close behind the lens, gives rise to the complaint of objects appearing surrounded by a mist, and to impairment of the functions of the retina adjoining the effused blood.

Rarely is the hæmorrhage so considerable as to occupy a large portion of the vitreous chamber, and to reduce vision to perception of light. It is in such cases that it is mostly observed in both eyes either simultaneously or in succession.

Large clots of blood soon become freely moveable in the vitreous chamber. They settle during sleep at the most depending portion of the chamber, and the patient, on getting up, finds that vision is much clearer. Movements of the eyes disturb the clots, which is often accompanied by a sensation of aching.

When ascertaining the state of vision, especially in hæmorrhage following injury, we must remember that displacement of portions of retina may likewise have occurred.

Though the lower portion of the retina is the part which suffers most frequently, any other part may become displaced by injury. It is probable that the retina is either detached, or has otherwise been injured, if we find the sensibility to light of any portion, especially the lower parts of the retina, destroyed or much diminished. (See Displacement of the Retina.)

Treatment.

Among remedies which have been found of use in the removal of blood from the vitreous chamber, can be recommended the local use of atropia (continued for months) and the operation of iridectomy (whether there be increase of tension or not). In hæmorrhage into the hyaloid fossa, the removal of the lens, and the laceration of that fossa have been practised with success. In several cases of extensive hæmorrhage, reducing vision to perception of light, a large iridectomy has been followed by complete recovery of sight.

In a young medical man (the clots of blood having been in the vitreous chamber for several years) an iridectomy in each eye was followed by rapid disappearance of the clots. The patient, before the operation (May, 1863), was barely able to guide himself; in about three months after the operation he resumed his practice. A short time ago I learned that he continued well.

In another case one eye had been lost; and the other, before the iridectomy, was found so full of blood that no view of the choroid, retina, &c., could be obtained with the ophthalmoscope. There was perception of light, and the periphery of the retina was sensitive without increase of

tension. Vision was restored by the operation, so that six weeks later the patient could read ordinary type.

In a third case one eye had been lost by injury, which in the other eye had caused an effusion of blood upon the surface of the hyaloid fossa (as seen by lateral illumination). Vision was restored in that eye (so as to enable the patient to read with the aid of spectacles, and to follow his employment) by removing the lens, which was previously rendered opaque, and then by tearing an opening into the hyaloid fossa.

The blood had been there unaltered for eighteen months, and the entire retina, as regards perception of light previous to the operation, was found sensitive. The patient, operated on in 1861, has followed his employment uninterruptedly to the present time.

PUS IN THE VITREOUS CHAMBER. SUPPURATION OF THE VITREOUS SUBSTANCE.

The quantity of pus may vary from a few filmy delicate opacities (consisting of pus cells), suspended in the vitreous substance, to a uniform yellow opaque purulent fluid, occupying the whole of the vitreous chamber. In the latter case, if the pupil and lens are clear, a yellow reflection is readily perceived from the vitreous chamber even with the naked eye.

Acute suppuration of the vitreous substance is one of the signs of ophthalmitis. Circumscribed suppuration (especially close behind the lens near the ciliary processes, and appearing as grey or yellow and opaque floating membranes) is often observed in the course of cyclitis, choroiditis, &c. Some suppose the pus cells to have entered the vitreous chamber from the choroid; others attribute their appearance to the cells of the vitreous itself, which cells are most abundant, especially in those parts of the vitreous which lie within the ciliary processes.

In the superficial parts of the vitreous the pus cells are the most numerous; while in the centre (suspended in a large quantity of yellowish fluid among the membranes of the vitreous) they float more freely.

The colour and consistence of the vitreous during suppuration varies according to the changes of the other component parts, and of the adjoining tunics. In some cases we find yellowish fluid with pus cells only, in others numerous blood spots occur simultaneously.

The blood spots, which are frequently found among fibrin and blood, appear, on minute examination, as newly-formed convolutions of blood-vessels which anastomose with vessels of the retina and of the ciliary processes.

The subsequent changes in suppurating "vitreous" are similar to those

observed in suppuration of connective tissue. The pus gradually disappears, and a web of opaque fibrous bands and membranes, with blood spots, débris of pigment particles, bone, chalk, and even fungi, occupy the vitreous chamber. The opaque tissue is partly derived from hypertrophy of the normal nucleated fibres of the "vitreous;" it is partly of new formation, e. g. the result of excrescences of the connective tissue of the retina.

The changes in the vitreous chamber, as a rule, are accompanied by shrinking and displacement of other parts of the eye. In rare instances the retina becomes displaced (drawn away from the choroid by the shrinking of the contents of the vitreous chamber) without the shape of the eyeball being altered. In the majority of cases all the tunics participate in the shrinking.

CHAPTER X.

THE IRIS AND THE CHOROID.

THE IRIS.

ANATOMICAL AND GENERAL REMARKS.

The more important parts which enter into the structure of the iris are the contractile fibres, the elastic fibres, the pigment, the elastic laminæ, the epithelium, the blood-vessels, and the nerves.

The contractile fibres are pale, very thin, undulating, and nucleated; the nuclei are round, or oval. Mingled with these fibres are found others resembling very fine hairs, and containing numerous round nuclei.

The contractile fibres have a circular arrangement near the margin of the pupil, and are termed *the sphincter of the pupil.* At some distance from this, nearer the insertion of the iris, a smaller circle of fibres is observed. The fibres which radiate from those of the sphincter are termed *the dilatator of the pupil;* they are not well marked. The extreme margin of the pupil is thin.

The elastic fibres.—These have their origin in that portion of the posterior elastic lamina of the cornea which faces the aqueous chamber. The fibres form part of the anterior surface of the iris, and are the chief means of its attachment behind the cornea.

The pigment cells are found among the contractile fibres, and contain yellow, brown, or blue pigment granules. The posterior surface of the iris is occupied by "*the uvea,*" which consists of one layer of so-called epithelial cells. Each cell encloses a number of brown granules, similar to those in the hexagonal cells of the choroid.

The blood-vessels.—The two arteriæ ciliares longæ, and some of the arteries of the choroid, supply the ciliary muscle and the iris. These vessels possess a well-marked muscular layer, and near the insertion of the

iris, as well as close to the margin of the pupil, have a somewhat circular arrangement (Circulus arterialis minor). In other parts of the iris their course is also somewhat similar to the arrangement of the contractile fibres.

The veins pass from the iris backwards between the ciliary processes, and anastomose with the numerous veins which occupy the part of the ciliary processes near the ora serrata. In their course they receive veins from the ciliary processes, and some from the ciliary muscle. They also anastomose with those of the circular sinus.

The nerves follow the vessels in their course. They are derived from the third, from the ophthalmic, or 1st division of the fifth (which is the sensitive nerve of the iris), and from the sixth and sympathetic nerves. (See Ciliary Muscle.) Some suppose that the filaments of the third nerve, which act during accommodation, come from a different part of the brain to those which induce reflex movements of the iris. The "sphincter" of the pupil is not solely supplied by nerve filaments from the third, nor the "dilatator" by filaments from the sympathetic nerve. There merely exists a difference in quantity, i. e. one kind of nerve filaments is more numerous in the one set of contractile fibres than in the other.

The action of these two nervous supplies is regarded as antagonistic: for instance, if the influence of the third nerve is suspended, then the sympathetic produces a greater effect.

The elastic laminæ and epithelium.—Upon the anterior surface of the iris there is one layer of round, flat epithelial cells, separated from the iris by a very thin transparent membrane (elastic lamina); a similar though somewhat thicker membrane intervenes between the iris and uvea.

The following terms are made use of in the description of morbid and other changes of the iris.

The anterior and the posterior surface of the iris.—The former faces the anterior, the latter the posterior, aqueous chamber.

The somewhat circular elevation upon the anterior surface near the margin of the pupil is caused by a circle of arteries, which, when light is thrown obliquely upon the iris, produces a shadow that is hardly perceptible in myopic persons.

Part of the posterior surface, from the uveal margin of the pupil to near its insertion, glides upon the capsule of the crystalline lens during the alterations in curvature of the latter.

Insertion of the iris.—The iris has its insertion about $\frac{1}{14}$ inch behind the outer margin of the cornea.

The attachment of the anterior surface is effected by elastic fibres, that of the posterior surface by uvea and a transparent membrane, which intervenes between uvea and iris, and also between iris and ciliary muscle. This membrane, together with the tendon of the above muscle, is attached

to the walls of the circular sinus at the point where the fibrous and the elastic portions of the walls of the sinus meet.

Margin of the pupil.—We shall have occasion to speak of the uveal (posterior) margin (the one which glides upon the capsule of the lens), and of the anterior margin (the one which faces the cornea).

The pupil.—Most of the natural and morbid changes of the eye reflect themselves in the state of the pupil. The alterations of its size, shape, and colour assist us in our diagnosis, not only of changes in the iris, but of numerous ocular and cerebral anomalies. Light thrown upon the healthy retina causes contraction of the pupil by reflex action of the optic nerve in the brain (in the corpora quadrigemina, which are considered as reflex centres), upon the third nerve.

Terms used in reference to the mobility of the pupil.

The movements of the pupil are *normal*, or "the pupil acts well," if it responds to the requirements of health, as regards its contraction, dilatation, and its accommodative movements.

In an eye (Æt. 20) in which the diameter (medium dilatation) of the pupil is $\frac{1}{5}$ of an inch, we find that the pupil can become contracted to a diameter of $\frac{1}{12}$ of an inch, and can be dilated to a diameter of $\frac{1}{3}$ of an inch.

The distance of the margin of the pupil (medium dilatation) from the apex of the cornea amounts to about $\frac{1}{7}$ of an inch. The centre of the pupil is situated a little inwards from the axis of the cornea, and is carried still a little more inwards, and approaches the cornea during accommodation. The margin of the pupil, during all its movements, glides upon the capsule of the crystalline lens. The margin of the pupil advances towards or recedes from the cornea, according to the changes which take place in the curvature of the crystalline lens.

Contraction of the pupil is either *direct*, i. e. the result of some kind of stimulus applied to the same eye, or it is *indirect or consensual*, i.e. the result of some kind of stimulus applied to the fellow eye.

The pupil becomes contracted—

(1.) When looking at (accommodating for) near objects, or when looking through a "weak" concave lens.

The relation between the size of the pupil and the state of accommodation may be disturbed by anomalies in the optic nerve, or in those nerves which supply the iris, or in consequence of changes in the structure of the iris itself.

(2.) During the action of the muscles attached to the eyeball, more especially of the internal recti muscles.

(3.) On the stimulus of light.

(4.) On direct irritation of the fifth nerve, or of its ophthalmic branch,

or after division of the Gasserian ganglion. The contraction produced by division of the third and of the sympathetic nerve is attributed to reflex action in the ciliary ganglion from the irritation of these nerves being conveyed to the fifth. If the influence of the spinal nerves upon the iris is removed, the parts supplied by the cerebral nerves remain unrestrained, and as a consequence of uncontrolled action, contraction of the pupil follows.

The pupil is contracted during sleep from decrease (?) of sensibility of the fifth nerve.

(5.) On local application of medical agents, such as Aconitum napellus, Ruta graveolens, Opium, Physostigma venosum ("the Calabar bean").

(6.) After escape of aqueous humour, of vitreous substance, or of the lens.

The mobility diminishes with the advance of age.

A mobile pupil is no certain proof of the eye possessing sight. The pupil of a blind eye may contract when the eye is moved quickly. The pupil of a blind eye moves in concert with that of the healthy fellow eye.

We test the direct mobility of the pupil by making the patient face the light (the eye which is not under examination being thoroughly excluded), and by then repeatedly shading and again exposing to light the pupil under examination. Atropia should be applied if adhesions or other structural changes exist, or are suspected.

Dilatation of the pupil is the result of "contraction of the 'radiating' fibres of the iris."

The pupil becomes dilated—

(1.) When looking at distant objects ("relaxing the power of accommodation").

(2.) On diminishing the stimulus of light.

(3.) On the application of medical agents, as Belladonna, &c.

In describing morbid changes, use is frequently made of such terms as the pupil is of "medium size," "it is contracted," "it is dilated," "it acts in concert," "it is sluggish, fixed," &c., &c. Thus comparing it with the size and mobility of the pupil in health when tested with the same degrees of light, e. g. "the pupil is dilated" indicates that it remains dilated, when a healthy pupil, exposed to the same degree of light, assumes a medium size, or becomes contracted. It may be dilated to such an extent as to cause its margin to disappear behind the cornea, or it may, on the other hand, be contracted to the size of a small pin's head.

The pupil acts in concert, "or its consensual movements are undisturbed," if, while the mobility of the fellow pupil is examined, its movements are

similar to those of the pupil under examination, while its mobility may be deranged if tested by itself, the fellow eye being at the time kept closed.

"*The movements of the pupil are sluggish*" if the rapidity of contraction, or of dilatation, or of both, is below par. The cause of this may be found in changes in the texture of the iris, or in intra or extra ocular, or more frequently, in cerebral changes. A combination of several of these causes often occurs.

The "pupil is fixed" when it remains immoveable on being exposed to the stimulus of light. This may be from adhesions only, or from anomalies of innervation. For anomalies of mobility see Mydriasis and Myosis.

The size of the pupil bears no relation to the vascularity of the iris; for it may be wide or narrow, with but little blood in the iris.

Hippus or Nystagmus of the Iris.

These terms designate a rapid succession of contraction and dilatation of the pupil, independent of the stimulus of light, as is occasionally observed in hyperæsthesia of the retina, and in hydrocephalus.

Irododonesis (= *tremulous iris*).

Tremulous iris is observed if the iris loses the support of the crystalline lens. Paralysis of the iris, enlargement of the "posterior aqueous chamber," or elongation of the suspensory ligament, with fluid vitreous, may be the cause. Some portions only of the iris may be tremulous.

The pupil in health is generally circular.

It is termed *irregular* if portions of its margin advance more into its area than others. Irregularities are produced by adhesions, or as results of paralysis, or paresis of only some of the fibres of the iris.

Adhesions are, as a rule, the result of inflammation. Irregularities are observed in many presbyopic and in hypermetropic persons when attempting to look at objects held close.

The colour of the area of the pupil varies with the time of life, and chiefly depends upon alterations in the colour of the lens and vitreous substance, and also of the surrounding tunics. The area of the pupil is *clear* or black in healthy eyes, if the pupil is contracted and examined by the unaided eye. In old persons it becomes slightly greyish. The colour of the pupil should always be ascertained by lateral illumination, when even in the young eye it appears somewhat greyish, provided the lens, which reflects some of the light thrown into it, occupies the area. The area of the pupil appears "greenish" or "yellowish," according to the amount of saturation of the crystalline lens and vitreous with yellow colouring matter. Varieties

of colour are also produced by cataract, and by exudation, or pigment from the iris.

The "cat's eye pupil" (or a yellow or golden reflection from behind the pupil) may be produced by lymph, or by cancer, or by pus in the vitreous chamber, or by displaced retina.

In fair persons, and especially in albinos, with widely dilated pupils, the natural red reflection from the choroid may be perceived in certain positions of the eye.

A combination of anomalies of size, shape, colour, and mobility is frequently observed. In the examination by lateral illumination and in the local application of atropia we have two means of recognizing such anomalies when they result from iritis and adhesions. With the ophthalmoscope we ascertain those connected with intra-ocular and cerebral changes.

The following description of morbid changes in the iris has been in many instances derived from microscopic examination of the living eye.

THE CHOROID.

ANATOMICAL AND GENERAL REMARKS.

In the choroid we distinguish, (1.) *The region of the yellow spot*, i. e. the part which corresponds to the region of the yellow spot in the retina; (2.) *The equatorial region*, occupying the equatorial region of the eyeball; finally, (3.) *The ciliary region*, which extends from the ora serrata to the insertion of the iris.

The choroidal aperture lies between the retinal and sclerotic apertures, and, like these, surrounds the optic nerve. At that part of the aperture which is level with the elastic lamina of the choroid, a thin ring of concentric elastic fibres is found. In many otherwise healthy eyes we find the margin of the aperture more pigmented than the adjoining choroid, and thus giving rise to a black or brown crescent or zone round the optic disc. (See Plate V. Fig. 1.)

The ora serrata, to which the retina is firmly attached, is situated exactly on a level with a line drawn through the ocular insertions of the recti muscles. This is the line of demarcation between the ciliary region of the choroid and the portion of choroid which subtends the retina. An instrument thrust through the tunics in front of the insertion of the recti muscles does not pass through the retina.

In the choroid we distinguish *the ciliary nerves, the blood-vessels, and the pigment.* Portions of pigment remain attached to the sclerotic when removing the choroid. These are termed the *lamina fusca;* and when

examined minutely are found to be brownish or black shreds of pigment surrounding the ciliary nerves, the ganglion cells, and the vessels.

Next to the lamina fusca we find the *large veins* (*Venæ vorticosæ*), having *the stellate pigment cells* around and between them. These cells, which are most abundant between the venæ vorticosæ, give the choroid a more or less deep brown patchy appearance. The brown patches are smaller and more roundish near the optic disc (see Plate VII. Fig. 18) and in the region of the yellow spot; whereas they are more oblong and flask-shaped in the equatorial region. (See Plate VIII. Fig. 23.) Their peculiar shape (defining the outlines of the venæ vorticosæ) readily distinguishes them from blood-spots or from morbid pigmentations of the choroid.

Nearer the retina we find a more homogeneous and less pigmented portion of choroid; it consists of peculiarly arranged blood-vessels along with *unstriped muscular fibres, and ganglion cells.* The latter are roundish and have a diameter of ·002126 in. They frequently appear granular; each contains a large nucleus (diameter ·000551 in.) and is connected with nerve filaments of a diameter of ·000110 in. This part of the choroid joins *the layer of capillary vessels.*

The choroid is chiefly supplied with blood by the short posterior ciliary arteries (about 20 in number) which pass through the sclerotic near the optic disc, some at its inner, the greater number at its outer, side (in the region of the yellow spot).

Very small arteries pierce the sclerotic close to the optic disc. In the sclerotic round the optic disc these arteries form a plexus, which sends branches into the choroid, and among the optic nerve fibres. These minute arteries form loops round some of the bundles of nerve fibres, and anastomose with arteries of the optic disc and of the retina. This is the only spot where the vessels of the retina and optic nerve anastomose with vessels of the other tunics. The anastomoses are chiefly arterial, and only a few small veins can be traced from the choroid into the optic disc.

The anterior part of the choroid is also supplied by some arterial branches coming from the arteries of the ciliary muscle: each of these branches is separated from the next by several ciliary processes.

The choroid therefore receives its blood from the short posterior, and in a lesser degree from the long posterior, and from the anterior ciliary arteries. All these arteries become continuous with the veins through the medium of capillaries.

The individual *capillaries* cannot be seen in the healthy eye; they are very small (diameter $\frac{1}{1400}''$), and, when filled with blood, give a pale red colour to the choroid.

The loops of capillaries round the optic disc and in the region of the yellow spot are roundish and very close to each other; those in the equatorial parts are elongated and wider apart.

Most of *the veins of* the choroid pass through the sclerotic in the equatorial region.

The elastic lamina is a structureless, transparent, very thin membrane intimately connected with the capillaries. It presents on section a sharp outline, and resembles the elastic laminæ of the cornea. It intervenes between the capillaries and the layer of hexagonal cells, and is found throughout the choroid, and follows the undulations of the ciliary processes.

The layer of hexagonal cells, or the so-called choroidal epithelium, is situated immediately beneath the retina. This layer differs from true epithelium in that the same cells are meant to persist for life. The cells are well-defined, hexagonal-shaped, and stand side by side. Each cell contains a central (?) nucleus, and a single layer of granules, which stand side by side. The granules at and near the yellow spot have a more deeper colour.

Groups of hexagonal cells can be seen with the ophthalmoscope in all eyes upon the equatorial region; and in "fair" eyes, especially of children, upon most parts of the choroid.

Many of the granules in the hexagonal cells appear transparent, or nearly so, when viewed in certain directions. The outlines of the venæ vorticosæ can in most eyes be seen in the equatorial region, and in some eyes throughout the choroid, unless they are covered with stellate pigment cells.

Ciliary region of the Choroid.—The most important parts are the ciliary muscle, and the ciliary processes.

The ciliary muscle ("the ciliary ligament") appears as a greyish pink belt, about one-eighth of an inch broad, situated upon the outer surface of the choroid beneath the sclerotic and close to the margin of the cornea. The muscle is attached at the junction of the sclerotic and cornea, or, more correctly, at the junction of the fibrous and elastic portions of the walls of the circular sinus. It is also firmly adherent to the choroid, but only loosely to the sclerotic. It remains attached to the choroid when tearing the latter from the sclerotic.

The muscle, which is thickest close to the cornea, and becomes thinner gradually as it extends backwards, on section has a somewhat triangular shape, one angle being directed towards the circular sinus, another towards the ciliary processes, and the third towards the ora serrata.

A transparent substance (elastic lamina) intervenes between the muscle and the vessels and pigment of the ciliary processes; this extends from the ora serrata to the circular sinus.

The ciliary muscle is highly vascular. The veins prevail. Those which come from the surface of the muscle which adjoins the ciliary processes anastomose with the venæ vorticosæ, and carry off the largest quantity of blood.

The veins which emerge from the margin of the muscle nearest the cornea, anastomose with the veins of the circular sinus before passing through the sclerotic. It must also be remembered that the veins of the iris and ciliary processes *do not* pass through the ciliary muscle, while most of their arteries do.

The fibres of the ciliary muscle enclose oval or roundish nuclei. The course of the fibres which lie near the insertion of the iris, and nearest the ciliary processes, is somewhat parallel with the margin of the cornea. These are termed the circular fibres of the ciliary muscle, and lie in front of the margin of the crystalline lens. Portions of those circular fibres, which are situated at some distance from the circular sinus nearer the sclerotic assume a different course. They are named radiating fibres for the reason that, like those fibres of the ciliary muscle which lie next the sclerotic, they have a course which is somewhat parallel with the recti muscles of the eyeball. These fibres pass over and into the choroid.

The nerves, vessels, and connective tissue, together with the elastic fibres along the insertion of the iris, participate in the circular course of the fibres of the ciliary muscle. The latter, when contracting, are supposed to press (through the medium of the ciliary processes and the fluid between these and the lens) upon the crystalline lens, and at the same time to cause the insertion of the iris to recede.

Ciliary nerves.—These nerves, which are distributed to the cornea, iris, and ciliary region, come from the ophthalmic or ciliary ganglion. A branch of the third nerve enters this ganglion, as also do some filaments of the sympathetic (arising from the spinal cord and passing into the anterior roots of the two inferior cervical and the six superior dorsal nerves), and branches of the fifth nerve. The nerves which leave the ciliary ganglion to reach the eye are termed ciliary nerves. There are a few ciliary nerves which are derived directly from the naso-ciliary nerve.

The ciliary nerves, about sixteen in number, pass through the sclerotic near the optic disc, and between sclerotic and choroid to their destination. The nerves for the ciliary muscle subdivide on the outer surface of the muscle and form a close plexus. Small roundish or oval bodies are observed in even the finest nerve filaments of this plexus.

Ciliary processes.—These processes, about eighty in number (taking the small and large ones together), commence at the ora serrata, where they are slightly prominent. They become more prominent as they approach the margin of the crystalline lens; beyond the latter they bend forwards and outwards to join the insertion of the iris.

Slight linear elevations upon the posterior surface of the iris, extending up to the margin of the pupil, represent the termination of these processes.

The bulk of each process consists in greater part of convolutions of blood-vessels, which cause its surface to appear uneven.

The veins are continuous with the capillaries. A larger vein passes, as a rule, along the ridge of each ciliary process, and runs backwards towards the ora serrata. In each indentation between two processes a vein from the iris is found. The ciliary region is supplied with blood chiefly by the two long posterior and by the anterior ciliary arteries. Both the former pass very obliquely through the sclerotic, one beneath the inner and the other beneath the outer rectus muscle. The anterior ciliary arteries pass into the tendons of the recti muscles and (in an undulating course) along the surface of the sclerotic, nearly as far as the margin of the cornea, where they pierce the sclerotic to reach the ciliary region. Occasionally one of the ciliary arteries anastomoses with a palpebral branch.

The surface of the ciliary processes is covered with "epithelial" cells, which have a roundish shape. Those between the processes are filled with strongly pigmented granules.

Upon the elastic lamina which intervenes between the processes and the epithelium are found minute elevations which have a reticulated arrangement.

Upon the epithelium is the zonula which follows the contours of the processes. Arrived at the tips of the ciliary processes, the zonula splits up into two portions. The portion nearest the vitreous chamber becomes the suspensory ligament of the crystalline lens. The other portion remains in apposition with the processes, and passes on to the posterior surface of the iris, where on section it may be seen as an exceedingly thin transparent line.

The tips of these ciliary processes do not touch the crystalline lens. The intervening space is occupied by transparent fluid, and by the suspensory ligament.

In the Albino (when examined with the ophthalmoscope) the ciliary processes appear to advance more in the posterior aqueous chamber (though without touching the lens) when the pupil is dilated.

Senile changes.

The elastic lamina becomes thickened, semitransparent, and brittle; it can be torn off in flakes, and breaks easily. Upon its inner surface elevations appear, some of which are pediculated, others are flat or globular. They displace the hexagonal cells, and sometimes reach a considerable size; they are most frequently found along the ora serrata and near the choroidal aperture.

The elevations and depressions of the elastic lamina, where it covers the ciliary processes, increase in size and become darker, giving rise to a

more marked, grey, and opaque colour of the tips of the ciliary processes. Granules of chalk appear in the lamina. The nuclei in the walls of the capillaries become indistinct, and soonest in the capillaries of the region of the yellow spot. The walls of the capillaries and the substance surrounding them become thickened; this gives rise to inequalities in the diameter of the capillaries.

The pigment granules of the hexagonal cells change colour; many become darker.

The shape of the cells themselves becomes altered; some appear much larger, and many of the granules or even the cells disappear.

Examination.

The choroid, when examined with the ophthalmoscope in the healthy living eye, presents many peculiarities. It differs in appearance as regards colour in "dark" and "fair" persons. (See Plate V. Figs. 1 to 6.) From the colour of the iris we can foretell that of the choroid. The contrast between the brilliant red colour of the choroid in the eye with blue iris, and the almost neutral tint of the one with black iris, is very striking.

The colour of the choroid is one of the most striking features of the interior of the living eye. The brilliancy of the generally red colour depends upon the quantity and degree of tinting of the pigment, and upon the blood circulating in the choroid. The greater the quantity of light which is reflected from the inner surface of the sclerotic, and which returns through the choroid, retina, &c., to the observer's eye, the better can the details of the choroid be recognized. The sclerotic is to the choroid what the silvering is to the glass of a mirror.

The more pigment there is in the choroid the less light passes through it; and the less can the details of the interior of the eye be recognized with the ophthalmoscope.

Any opaque substances (clots of blood, &c.) intervening between choroid and sclerotic prevent our seeing that part of the sclerotic and choroid.

To be able to examine the choroid thoroughly the pupil should be well dilated. The whole of the choroid, from the optic disc to near the ora serrata, can be seen with the ophthalmoscope, and in albinos also the tips of the ciliary processes. Particular attention should be paid, (1.) To "*the choroidal aperture*," i. e. to the choroid where it surrounds the optic disc. (2.) To *the region of the yellow spot*, which is readily seen by directing the patient to look at the sight-hole of the ophthalmoscope. (3.) To *the equatorial region*, which becomes visible on looking slantingly into the eye.

The details of the structure of the choroid which can be recognized by direct ophthalmoscopic examination are, groups of hexagonal cells, groups of stellate pigment cells; the veins (venæ vorticosæ), and the ciliary arteries.

The hexagonal cells (i. e. their pigment granules) appear more translucent when the light traverses them obliquely; and more so in some eyes, or in some parts of the same eye. The granules of many cells have a deeper brownish tint. Groups of such cells, when standing side by side with cells containing less tinted granules, cause the inner surface of the choroid to appear sprinkled with groups of minute brown spots. The recognition of the situation of the hexagonal cells is an important means of localizing morbid changes in other parts of the choroid and retina. Morbid changes, occurring in these tunics, hardly ever fail to be accompanied by alterations in the hexagonal cells.

The groups of stellate pigment cells, which occupy the spaces between the veins of the choroid, appear as small defined patches, varying in colour from light to dark brown. The peculiar honeycomb appearance (see Plate VII. Fig. 18) of a strongly pigmented anæmic choroid is produced by the pigment patches which surround the nearly empty veins. An abundance of these strongly tinted stellate pigment cells, when intervening between the veins and the hexagonal cells, gives the choroid a more uniform brown red colour.

Development of the Choroid, Iris, Ciliary Processes, and Ciliary Muscle.

The Choroid. About the end of the first month of fœtal life portions of the stellate pigment cells of the choroid are perceptible before any other parts of the choroid can be recognized; the layer of hexagonal cells appears about the third month. At this period some of the cells are nearly transparent, others have a darkish lilac colour. One portion of a cell may be found filled with pigmented granules, while none are yet visible in other portions. Many of the hexagonal cells are not filled with pigment granules even at the sixth month. The lilac colour gradually changes into a brownish one, of varying intensity. The pigmented granules in these cells appear first at the periphery of each cell.

Wherever the pigmentation is most advanced, there we find the vascularity of the choroid greatest; whereas no vessels are perceptible in the non-pigmented parts. During the third month the choroid appears as a blackish or yellowish membrane, extending from the optic disc to the junction of the sclerotic and cornea.

The blood-vessels of the choroid (as those of other parts of the eye) are supposed to result from the union of round cells. These cells at first form a kind of membrane, which changes into a sulcus, and finally into a tube. Lateral prolongations of primary tubes give rise to new vessels. The cells which remain within these tubes are supposed to change into blood corpuscles.

The Ciliary Processes. About the end of the third month the ciliary

processes are observed along the margin of the choroid next the cornea. They appear as small folds, which project from the inner surface. Portions of a thick blood-vessel, which runs along the margin of the choroid, are seen projecting into these folds; while a second blood-vessel, placed parallel to the first, freely anastomoses with it.

A bluish membrane appears upon that surface of the ciliary processes which lies nearest the vitreous chamber. The pigmented cells observed in this membrane do not extend quite up to the most prominent portion of the ciliary process.

The tip of each process is free from pigmented cells, and blood-vessels can be seen; while in the remaining portion they are hidden from view by pigment.

The Ciliary Muscle makes its appearance about the middle of the third month.

The Pupillary Membranes.—We distinguish an anterior and a posterior pupillary membrane; the latter can be recognized a considerable time before the former.

The posterior pupillary membrane is placed between the capsule of the crystalline lens and the cornea, and appears to be a continuation of the bluish membrane which covers the ciliary processes.

The iris, advancing from the ciliary processes between the cornea and this membrane, comes in contact with the anterior surface of the posterior pupillary membrane. The anterior pupillary membrane appears later, and originates as a vascular membrane from the ciliary muscle, interposing itself between the iris and cornea. Its posterior surface is in contact with, and adherent to, the anterior surface of the iris.

About the ninth month that part of the membrane which lies in front of the area of the pupil undergoes "atrophy," the blood-vessels becoming obliterated and the membrane perforated. A similar change is said to occur in the posterior pupillary membrane.

The Iris.—At the commencement of the fourth month, soon after the appearance of the ciliary processes, traces of the iris are observed; a narrow grey rim appears in front of the ciliary processes. This rim is attached to the choroid by delicate filaments, leaving open spaces, through which we can see into the vitreous chamber.

This rim of iris gradually becomes broader. When viewing its anterior surface a circular arrangement of fibres is observed. At the end of the sixth month so-called radiating fibres are observed, while the circular fibres near the insertion of the iris are lost sight of.

Branches of the ciliary arteries, coming from the choroid, pass over the ciliary muscle into the iris; parallel with these the veins return.

The iris, until the "uveal pigment" is formed, has a greyish semi-transparent colour.

The pigment of the iris becomes developed soon after the uveal pigment. The membrane in which the uveal pigment appears, is a prolongation of the one which covers the ciliary processes. From the ridge of each ciliary process a filament is prolonged across the uvea up to the margin of the pupil. These filaments give the uveal surface of the iris a somewhat striated appearance; the slightly projecting striæ radiate from the pupillary margin.

Congenital Anomalies of the Choroid and Iris.

The fœtal fissure.

At one period of fœtal life a large opening, termed *the fœtal fissure,* is observed in the tunics of the eyeball. The opening extends from the spot where the optic nerve joins the sclerotic to the nearest margin of the cornea, and leads also into the nearest brain cell.

The margins of this opening (termed "fissure") gradually approach each other. They meet first at the lowest point near the equator of the eyeball; thence the closure advances towards the cornea, and more slowly towards the optic nerve.

The tunics generally close simultaneously, though closure of the sclerotic has been observed to precede that of the choroid.

About the middle of the third month all trace of the fœtal fissure has disappeared at that part of the choroid from which the ciliary processes originate. Further back, towards the optic disc, the fissure is not quite closed at the end of the third month.

An arrest of union of one or of all of the tunics which form the margins of the fissure is termed *Coloboma.*

The sclerotic near the fissure remains very thin for some time. During one period of development it projects towards the orbit in the region of the yellow spot, when it is termed *the sclerotic protuberance.* This protuberance is somewhat conical, and is thinnest at the most prominent part. It gradually becomes less prominent, while the outer (fibrous) layer of the sclerotic increases.

The eye undergoes a change of position (rotation round its axis) about the time when the last part of the fissure closes; and the part which at first was situated at the lower margin of the optic disc comes to lie on its outer side.

Coloboma, as stated above, signifies an incomplete closure of the fœtal fissure, i. e. of the tunics which meet at the fissure. The varieties which are most conspicuous are, coloboma of the iris, and coloboma of the choroid.

Coloboma of the Iris.

The pupil in coloboma of the iris (cleft Iris), instead of being round, has a pear-shaped figure. The pointed part of the pupil in most cases extends downwards, sometimes downwards and outwards, and in rare cases upwards. In one case it was placed horizontally.

Coloboma occurs, as a rule, in both eyes, but has been observed in one eye only. Two colobomata (clefts) have occurred in one iris. The sphincter of the pupil projects sometimes from either side into the cleft. The margin of the latter appears fringed with black if the fibrous layer of the iris is more cleft than its uveal part. With the ophthalmoscope it has been ascertained that in some cases no cleft exists in the uveal part.

Coloboma has occurred in members of the same family in several succeeding generations, and has then disappeared again. The complications observed with coloboma of the iris are: coloboma of other tunics; impaired vision; albinoism; anomalies in the shape of the cornea, or of the entire eyeball; oscillation of the eyeball; ptosis, and cleft in the eyelids.

Coloboma of the Choroid.

The existence of the coloboma is diagnosed with the ophthalmoscope. Coloboma of the choroid is always accompanied by anomalies of the retina, with corresponding impairment of vision, and by an abnormal shape of the eyeball.

The sclerotic, instead of assuming the natural curvature and thickness, remains thin and bulged (staphylomatous) in some of the parts formerly occupied by the fœtal fissure. The oval elongated shape of the myopic eye is thought to depend upon this condition, though it must be remarked that coloboma has also occurred in highly hypermetropic eyes.

The most striking change observed with the ophthalmoscope is a brilliant white figure about the region of the optic disc, extending however in extreme cases forwards to the ciliary processes, or even to a coloboma in the iris.

This figure presents a variety of shapes. Sometimes we find it close to the optic disc and resembling a brilliant grey or bluish-white atrophic optic disc. The pink colour and the retinal blood-vessels assist in recognizing the optic disc itself.

The white figure is the result of incomplete closure of the sheath of the optic nerve where it joins the sclerotic, and of the tunics immediately adjoining it.

A nearly transparent membrane (? the retina) may sometimes be seen extending from the margin of the optic disc over the white figure.

This membrane, as may be seen in a preparation preserved in the Museum of Guy's Hospital, has been found perforated, and has thus given rise

to an opening of communication between the vitreous chamber and a staphyloma of the choroid and sclerotic.

In some cases it appears as if the optic disc had been separated into an upper and a lower half by a large intervening portion of white staphylomatous tissue. In most cases the figure is pear-shaped, tapering off towards the iris and becoming wider as it approaches the optic disc.

In some a rim of normal sclerotic, choroid, and retina intervenes between the optic disc and the coloboma.

The margins of the white figure are abrupt. The white colour is due to the sclerotic, which, judging from the course and abrupt bend of the vessels of the retina, where they pass round the margin of the figure, is more or less staphylomatous. Intervening between the natural colour of the choroid and the margin of the figure, we often observe a brownish or black pigmentation which is ascribed to thinning of the choroid.

Drawings of varieties of coloboma are preserved at Guy's Hospital.

Vision is always impaired, partly by complications occurring with coloboma, and chiefly by the absence of the perceptive elements of the retina in the area of the white figure.

The Albino.

The albino is recognized in the majority of cases by the white or yellowish-white colour of the hair, eyebrows, and eyelashes; by the pink reflection "from the iris" and pupil; and by a certain amount of intolerance of light accompanied by what sometimes is termed "short sight."

In one case blue irides with brown hair were observed, in another the choroid presented the appearance peculiar to albinos, while the iris and hair had a brown colour.

In extreme cases we observe (on looking with the ophthalmoscope through the pale bluish semi-transparent iris) the irregular margin of the crystalline lens.

The optic disc appears well defined, and has a deep pink colour. In some cases a silvery white crescentic figure is seen skirting its upper margin.

The retina in an eye with brown iris presented two brown dots in the region of the yellow spot.

The most prominent peculiarities of the choroid of the albino are—

(1.) Apparent absence of blood in the capillaries of the choroid, probably due to absence of these capillaries.

(2.) No pigment in the granules of the hexagonal cells.

(3.) Very defective pigmentation of the stellate pigment cells of the choroid.

These anomalies give the "tunics," when viewed with the ophthalmoscope, a brilliant yellowish-white appearance. In extreme cases they

extend throughout the choroid. The anomalies as regards the capillaries are generally confined to the region of the yellow spot, and to the part which surrounds the optic disc.

At varying distances from the optic disc the large choroidal veins disappear beneath a more brilliant uniform red colour, which is supposed to be due to blood in the choroidal capillaries.

Treatment.—Stenopæic spectacles, with weak convex lenses, assist materially in reading.

Irideremia, or Absence of the entire Iris.

Varieties of irideremia are—(1.) Absence of all the parts of the iris except the uvea; and (2.) Absence of the circular fibres, or of the radial fibres, of the iris.

Irideremia, as a rule, occurs in both eyes, and is frequently complicated with peculiar opacities of the cornea together with "cataract," sometimes with atrophic changes of the optic disc and absence of the retinal blood-vessels.

With the ophthalmoscope we readily see the margin of the crystalline lens and the space intervening between it and the ciliary processes.

Vision.—Patients have been known to pass through life and to attend to their work without applying to the oculist. They sometimes seek assistance when presbyopia sets in. Stenopæic spectacles, and those with convex lenses, have been found of service.

Persistence of the Pupillary Membrane.

Portions of this membrane are frequently met with upon the anterior surface of the circular fibres of the iris near the pupil. They generally encroach upon the area of the pupil as greyish-white and opaque filaments. If adherent to the capsule of the crystalline lens, they are found relaxed during contraction and stretched during dilatation of the pupil. In one case the entire pupil was found masked by the perforated pupillary membrane. In another case the entire iris and pupil were partially obscured; through holes in the membrane the pupil could be seen to contract and dilate normally.

Displacement of the Pupil

Occurs most frequently upwards. Displacement of the pupil behind the margin of the crystalline lens has been observed. An irregularly-shaped (frequently oval) pupil is sometimes the sequel of intrauterine iritis. Too small a pupil with tremulous iris, and too large an one, have occurred.

Several Pupils.

Cases are recorded of two or three pupils occurring in the same iris, either near the natural pupil or more towards the insertion of the iris, all becoming dilated by Belladonna. An explanation of this anomaly may be found in the fact that the iris at first is attached to the choroid, not in a continuous line, but by numerous isolated fibrillæ.

Anomalies in Colour.

The iris of one eye may have a brown, and that of the fellow eye a bright yellow, or a blue colour. It is not uncommon to find one half of the iris to have a blue, the other a brown colour.

The circular fibres of the iris frequently differ in colour from the radiating fibres.

In a brown iris the margin of the pupil is lighter, and in a blue one darker, than the other parts.

White opaque, frequently concentric, lines occur on the surface of the iris near its periphery. Pigmentations, generally of a rust colour, are met with upon the iris midway between the pupil and the insertion of iris.

INJURIES OF THE IRIS AND OF THE CHOROID.

Incisions, dividing the radiating fibres of the iris transversely, if made in a direction parallel with the fibres, can, even with the ophthalmoscope, only be recognized with difficulty.

Separation of the iris from its insertion, however small, betrays itself by irregularity of the pupil. The separated portion never becomes adherent again.

Rupture of the sphincter and of the margin of the pupil have given rise to traumatic coloboma.

Hyperæmia follows these injuries, but rarely iritis.

Rest of the injured eye and of the sound eye, if inconvenience is felt from using it, and the local treatment for iritis are required, and continued until all undue vascularity has disappeared.

Prolapse of the iris, when it occurs through a wound in the cornea or sclerotic, should, if covered by conjunctiva and not bulging, be left alone; but if bulging it should be punctured with a needle and the collapsed protruding portion should be seized with the forceps, and removed with scissors. Care must be taken not to cut off the protruding iris too close to the eyeball, but to leave a little along the margin of the wound, or else a fistula may remain.

Rest of the eye and closure of the lids by a bandage are required until all undue vascularity has subsided.

A large prolapse of the iris may be changed into a flat cicatrix by puncturing it in numerous places every second or third day.

Foreign bodies in the iris, whether visible or merely suspected to be there, require the immediate performance of iridectomy to remove the injured or suspected portion of iris. See also Traumatic Cataract.

Concussion of the iris by blows, &c., may cause—

(1.) Mydriasis. In every case we should ascertain with the ophthalmoscope the state of the deeper parts of the eye. By making the patient look through a small opening we determine whether the impairment of vision is due to the Mydriasis only.

If vision (tested by these means) is found normal, no immediate fear need be entertained.

The eye is kept at rest, and Calabar is applied locally, if after a few weeks the pupil has not resumed its natural size and mobility.

(2.) Partial or complete disappearance of the iris. This has been observed after blows on the eye, causing partial or entire dislocation of the vitreous substance and of the crystalline lens, these being simultaneously rotated within the area of the retina. The iris, or part of it, becomes drawn backwards, and is kept out of sight through vitreous substance pressing it against the ciliary processes.

In an eye with apparent absence of the iris (which had been blind for years) a chalky lens was seen rolling about in the hyaloid fossa, whilst the iris after excision was found pressed upon the ciliary processes by aqueous humour.

Rupture of the sclerotic is often accompanied by displacement of the portion of iris adjoining the seat of injury.

The kinds *of injury of the choroid*, which have come under observation, have been perforating wounds; concussion of the choroid; foreign bodies (pieces of metal, glass, &c.) lodged in or near the choroid; and injuries of adjoining tunics, secondarily implicating the choroid.

The regions of the choroid most frequently injured are the ciliary region and the one above and below the yellow spot.

The morbid changes following injury of the choroid vary according to the general health of the patient, the nature of the injury, the parts injured, the state of the eye previous to the injury, and the treatment adopted.

The same kind of injury may be followed by suppurative choroiditis in a weak person, which in a strong one gives rise to a less destructive form of inflammation.

A foreign substance lodged in the choroid gives rise to a graver injury than an incised wound, or a concussion of the choroid.

Injuries about the region of the yellow spot are more serious, in consequence of their frequently implicating parts of the retina which are essential for direct vision; and injuries about the ciliary region, in consequence of their giving rise to sympathetic changes.

An injury of the choroid of an eye, which previous to the injury was neither "glaucomatous" nor otherwise morbidly altered, is less grave in its consequences than one occurring to an unsound eye.

The morbid changes most frequently observed in the choroid after injury are Hæmorrhage (see Hæmorrhage into Choroid); Suppuration (see Ophthalmitis and Choroiditis); Plastic Choroiditis (see Choroiditis); Glaucoma.

Rents in the choroid.—Owing to some peculiarity in the structure of the choroid, we find the margins of the rent wide apart if the rent runs transversely, i. e. if it has a direction parallel with the margin, e. g. of the cornea.

Rents of the choroid have been observed after concussion of the eyeball by blows, without any of the other tunics appearing ruptured. Viewed with the ophthalmoscope the rent appears as a white or brilliant white irregularly-shaped surface. Its long axis runs somewhat parallel with the margin of the cornea. It is skirted by pigment spots, and retinal blood-vessels may be seen passing across its area.

The treatment of injuries of the choroid is, in a great measure, included in that of the morbid changes which follow the injury.

Foreign bodies lodged in or near the choroid have repeatedly been removed successfully.

The injured eye and the fellow eye, if sympathetic irritation appears, should in all cases be kept at absolute rest until all signs of irritation or of inflammation have disappeared.

TUMOURS OF THE IRIS.

Tumours, advancing from the deeper parts of the eye, in their course often implicate the iris. (See Orbit, Tumours in the, &c.)

The following are instances of tumours originating in the iris:—

A globular tumour, with a dirty yellow flocculent surface, and consisting of myaloid corpuscles and connective tissue. In one case the tumour increased in size, and finally became complicated with hypopion, corneitis, and perforation of the cornea. Sometime later this was followed by shrinking of the eye.

A whitish tumour (diameter $\frac{1}{10}''$), with a shining surface, projecting from the anterior surface of the iris near the margin of the pupil, was re-

moved. It proved to be covered with epithelium, and to contain a white chalky substance, and a few short hairs.

Sebaceous tumours have been known to cause circumscribed suppuration of the iris and cornea.

A small pigmented tumour of the colour of the uvea, near the margin of the pupil, has been observed. It accompanied the movements of the iris.

Cysts (situated near the margin of the pupil) enlarge very slowly at first; they become painful as they increase, and resemble the bulging of a circumscribed portion of iris, as is sometimes seen after severe iritis with synechia. The cyst or cysts may at last come in contact with the cornea; and sometimes occupy the entire anterior chamber, and hide the pupil. They are generally situated between the uvea and the fibrous part of the iris.

When punctured fluid escapes, the cysts collapse and the iris resumes its natural appearance. They fill again, and do not always disappear after repeated puncturing.

A cysticercus appearing in the shape of a small black nodule, and attached to the anterior surface of the thickened and vascular iris, has been removed successfully.

For tumours of the Choroid, see Orbit; Tumours of the Orbit and Eyeball.

PARALYSIS.

The iris, if completely paralysed, is tremulous (*Iridodonesis*), and the pupil is of medium size and fixed.

Mydriasis signifies an abnormal dilatation; *Myosis*, an abnormal contraction of the pupil.

Mydriasis, or abnormal dilatation of the pupil, may arise from—

(1.) Paralysis of those branches of the third nerve which supply the iris. This condition by some is termed the *paralytic*, to distinguish it from the *spasmodic* form of Mydriasis.

The pupil is not dilated to its utmost. It remains fixed when exposed to bright light and during accommodation. It often contracts somewhat when the external rectus muscle (supplied by the sixth nerve) acts.

(2.) Irritation of the sympathetic nerve. This gives rise to greater dilatation of the pupil than the preceding.

The *causes* of Mydriasis may be—

Glaucoma,—injuries,—morbid changes of the brain, as hydrocephalus, meningitis, or hæmorrhage at the base of the brain,—poisoning by gas, by Belladonna, Hyoscyamus niger, Veratrum album, Œthusa Cynapium, Strychnia, Cicuta virosa, Digitalis purpurea, Hydrocyanic acid.

Mydriasis, if confined to one eye, is generally caused by changes in the eye itself or by circumstances acting locally upon the eye. The pupil is either fixed or sluggish, and often irregularly dilated, while the fellow pupil appears unusually contracted. Mydriasis is generally combined with paralysis of the ciliary muscle, and often with paralysis of other muscles supplied by the third nerve. It has been observed to be the forerunner of mental derangement.

Treatment.—The local application of calabar should be tried in all cases of non-glaucomatous origin, and should be continued as long as improvement of vision is observed. The "mydriatic" eye, if it resists calabar and interferes with the use of the other eye, must be kept closed.

Vision is often but little disturbed if the mydriasis is confined to one eye. Patients complain of the light being too dazzling, and of inability to distinguish near or small objects. In the selection of spectacles for reading, we must be guided by the existing state of refraction and accommodation.

Mydriasis as a symptom of increased tension comes under the treatment of glaucoma.

We should direct our attention also to the cerebral changes that may exist or threaten.

Myosis, or abnormal contraction of the pupil.—Myosis generally exists in both eyes. It may be of the spasmodic or of the paralytic kind. When of the former variety, the pupils respond to the agents which produce dilatation.

As causes have been observed—

(1.) Hyperæsthesia of the retina brought on by continued work at small objects.

(2.) Paralysis or paresis of the branches of the sympathetic nerve which go to the iris (with or without irritation of the third nerve); from morbid changes about the medulla oblongata (as precursor of spinal amaurosis); or from pressure upon the sympathetic nerve in the neck (by large tonsils, or by aneurism of the subclavian artery).

(3.) Spinal or cerebral disease.

(4.) Long-continued and close work.

(5.) Contraction of the pupil, following division of the fifth nerve, is probably a reflex action of the irritated cerebral portions of the third nerve.

Treatment.—Solutions of atropia of varying strength may be tried (to dilate the pupil to a moderate extent) if the diminution of the field of vision and the desire for light are great.

In some cases of cataract with Myōsis, the latter resisting atropia, iridectomy has had to be performed previous to extraction, in order to enable the cataract to pass in front of the iris.

ANOMALIES OF ACCOMMODATION.

The anomalies of accommodation which arise from abnormal changes of the crystalline lens are described under Presbyopia, under Dislocation of the Lens, and under Aphakia. We shall treat here of those which arise from disturbed action of the ciliary muscle itself, and distinguish, (1.) Paralysis or Paresis. (2.) Weakness. (3.) Spasm.

Paralysis of the Ciliary Muscle.

Causes and General Remarks.—We must, if both eyes are affected, look for a central cause (cerebral disease, syphilis, tumours).

The immediate cause is paralysis of the nerve fibres which supply the ciliary muscle. In a large number of cases, we find simultaneous paralysis of other fibres of the third nerve, producing ptosis and paralysis of the external muscles of the eye.

The iris and ciliary muscle are very rarely found unaffected when other parts supplied by branches of the third nerve are paralysed: and again, paralysis of all the branches of the third nerve is uncommon, while paralysis of the ciliary muscle (of the accommodation) and of the iris alone is not unfrequent. In the latter cases only the short root of the ciliary ganglion is paralysed.

This paralysis has been observed at all ages, but more frequently in young and in middle-aged persons. In all cases we should examine the functions of other nerves (of the fourth, sixth, and also of the fifth nerve).

Symptoms.

(1.) Loss of contractility of the sphincter of the pupil. The pupil is immovable, of medium dilatation, and accommodative and reflex movements are absent. The pupil may remain slightly movable (paretic) while the accommodation is paralysed, or, on the contrary, the latter may be found tolerably good while the pupil remains fixed.

(2.) Loss of contractility of the ciliary muscle. Vision at distance is generally normal, unless there is some anomaly of refraction. Vision for near-work, reading, &c., is more or less disturbed if only one eye is affected; it is impossible if both eyes are implicated.

Myopic persons, who wear spectacles, are as much inconvenienced as Emmetropics; while, if no spectacles are worn, and the myopia is such that the farthest point of distinct vision lies about at the distance at which the book, &c., is held, little disturbance is felt. Patients sometimes complain of objects appearing too small, and, if the recti muscles are implicated, of their appearing to move. Patients also mistake the positions of objects.

Treatment.

The constitutional changes which may have given rise to the paralysis are syphilis, rheumatism, general weakness following severe illness, &c.; these require appropriate medical treatment.

The local treatment, if only one eye is affected, consists in the application of calabar until the accommodation is restored. Calabar should also be tried if both eyes are affected, though it is of little use if the cause of the paralysis be cerebral.

Spectacles with convex lenses are necessary for work. The lenses should be of the focal distance at which the patient wishes to see distinctly when at work, e. g. spectacles with lenses (each lens having a focal distance of 16″) are required if work has to be performed at that distance.

The local treatment of paralysis of other branches of the third nerve has to be combined with this.

Paresis of the Ciliary Muscle. Paresis of Accommodation.

Causes.—Paresis is frequently observed after acute disease. A cause which of late has attracted much attention is diphtheria. The paresis appears suddenly after the specific lesions of diphtheria have nearly, or quite, subsided. Accommodation and speech are often the only functions impaired. Other causes of paresis are those enumerated under Paralysis.

Symptoms.—The patient (with the affected eye) can only with difficulty, or not at all, read No. I. at 1′, No. II. at 2′, or No. III. at 3′, but can recognize distant letters, e. g. No. XX. at 20′, provided all other parts be normal.

Myopic persons, who do not wear spectacles, may experience no inconvenience if the myopia is such that the farthest point of distinct vision lies at about the distance at which reading, work, &c., is performed.

Paresis of accommodation may be mistaken for asthenopia.

Paresis appears rapidly within a few days or weeks; asthenopia has often existed for years before the patient seeks advice. In paresis prolonged vision of distant objects causes no inconvenience. Near objects cannot be recognized, or only with difficulty, fatigue appearing almost immediately after the attempt has been made to see them distinctly.

In asthenopia, on the contrary, fatigue appears after prolonged vision of distant, as well as of near, objects. Objects can be recognized distinctly for some time, though vision be painful.

Treatment.

The treatment is similar to the one adopted for paralysis. Besides the local application of calabar, we may try secale cornutum, to be given in

ten-grain doses (with carbonate of magnesia, or with iron) four times daily for a few weeks.

Spasm of the Ciliary Muscle (Painful Vision).

The characteristic symptom of spasm of the ciliary muscle is pain felt in the eyes, e. g. during " near work " (" during tension of the ciliary muscle "), or after application of a strong solution of calabar. The pain continues during tension of the muscle ; it subsides after repeated application of atropia. The pain may be so severe that all work has to be discontinued; it often appears suddenly, and is accompanied by myosis.

Causes of painful contraction of the ciliary muscle are—

(1.) Insufficiency of the internal recti muscles, with hypermetropia.

(2.) Frequent efforts at accommodation for the nearest point of distinct vision as occur in amblyopic and in astigmatic persons.

(3.) Moderate degrees of hypermetropia, inducing persistent efforts to overcome the hypermetropia.

(4.) Myopia, partly from undue tension of the accommodation during prolonged work, partly from hyperæmia within the eye extending to the ciliary muscle.

Treatment.

Near work, reading, &c., may have to be discontinued for months if the treatment of the cause (i. e. the anomaly of refraction or the insufficiency of the recti muscles) does not, within a few weeks, remove the pain and make prolonged work easy. Spectacles must then be laid aside ; and the ciliary muscle must be thoroughly paralysed by atropia, and kept in that condition. Spectacles, with tinted convex lenses, may be given to hypermetropic persons for going about. Plain tinted glasses are ordered for the same purpose in all other cases.

IRITIS (INFLAMMATION OF THE IRIS).

General Remarks.

Different forms of iritis have received special names, some of which are derived from the cause (such as syphilitic, traumatic, &c., iritis); others from the course (as acute, chronic, recurrent, &c., iritis) ; others from the nature of the " inflammation " (as suppurative, serous, plastic, &c., iritis).

In each special form of iritis we meet with symptoms which occur in every case of iritis, and with symptoms which characterize the special form.

We shall distinguish,

(1.) Simple iritis ;

(2.) Syphilitic iritis ;

(3.) Traumatic iritis (following injuries and operations), together with the peculiar form described as Sympathetic iritis;

And (4.) Serous iritis.

The symptoms of simple iritis are always mixed in varying degrees with those of the special forms; so also those which are characteristic of a special form of iritis may pass away, and the case run on as one of simple iritis. This should be borne in mind when treating iritis. A trial should be given in all cases to a combination of the local treatment of simple iritis with any general medical treatment that may be thought fit.

The symptoms characteristic of the special forms are—for syphilitic iritis the separate nodules of lymph;—for sympathetic iritis the unusual enlargement of the vessels of the iris;—for serous iritis the enlargement of the pupil, combined with increased tension, and increased quantity of aqueous humour.

An embolic or metastatic iritis has been described as occurring during, or soon after, an attack of measles, scarlatina, variola, typhoid or rheumatic fevers; or during pregnancy, or whilst nursing, &c. The iritis in these cases is, as a rule, partly plastic, partly suppurative in character, and accompanied by inflammation of other parts of the eye. Syphilitic iritis, when occurring in very debilitated persons, may be accompanied by hypopion, or by an abscess in the iris.

The *injuries* which frequently cause iritis of the simple or of the suppurative form are operations for the removal of cataract, and wounds or concussions of the cornea.

Iritis often appears as a complication of morbid changes in other parts of the eyeball, e. g. during an attack of glaucoma, with tumours or entozoa within the eye; during choroiditis, during corneitis, &c.

Simple Iritis.

Iritis is probably always preceded by hyperæmia of the iris, with slight redness of the sclerotic adjoining the margin of the cornea; by impaired mobility and by some discolouration of the iris. A similar hyperæmia of the iris is also observed during morbid changes in the ciliary processes, choroid, retina, cornea, and even of the conjunctiva.

The presence of hyperæmia should put us on our guard, not only because it readily increases to iritis, but also because it often indicates a grave disturbance of other important textures of the eye.

The symptoms which are common to all forms, and which are characteristic of iritis, are:

(1.) A varying amount of "plastic" material in, upon, and round the iris.

(2.) Impairment, or complete loss, of mobility of the iris generally, with adhesions (synechiæ) of the uvea to the capsule of the lens.

(3.) Irregularity in the shape of the pupil.

(4.) Alteration in the colour of the iris.

(5.) More or less sclerotic vascularity along the margin of the cornea.

The appearance of "plastic material" or of "inflammatory products" is attended with anomalies in the nutrition and texture of the iris. The iris, near the margin of the pupil, appears most altered. The plastic material, seen with the naked eye, generally appears as a greyish, semiopaque substance, which is diffused throughout the iris, or appears as spots of varying size. It gives rise to adhesions of the iris to adjoining parts.

The chemical properties of the aqueous humour are altered. The latter often becomes turbid from the presence of mucus and pus corpuscles. Hypopion may appear simultaneously. Diffused opacities, or minute spots, may occur (especially at the lower half of the posterior surface of the cornea), which are partly the results of effusion, partly of alterations in the epithelium.

The dotted opacities are characteristic of syphilis (both inherited and secondary).

The terms *Aquo-capsulitis, Hydromeningitis,* were formerly used to designate the form of iritis which is accompanied by the appearance of opaque spots upon the posterior surface of the cornea.

The quantity of plastic material may be so small that the irregularities of the pupil, which appear on the application of atropia, are the sole signs of iritis; it may be so great that the swollen iris comes in contact with the cornea. The plastic material impedes the movements of the iris; and its subsequent changes more or less destroy the texture of the iris.

The margin of the pupil, though no adhesions may exist, loses its mobility, and often its regular shape.

Synechiæ, or adhesions of the Iris to other parts.

We distinguish *Anterior and Posterior Synechiæ.*

Anterior synechiæ, i. e. adhesions of the iris to the cornea, or to textures occupying its place. Synechiæ, if occurring without perforation of the cornea, are often observed near the insertion of the iris; and are the result of the prolonged contact of the swollen and inflamed iris with the cornea. Swelling of the inflamed cornea facilitates these synechiæ.

Posterior synechiæ, or adhesions of the iris to the parts situated behind the uveal surface. They are by far the most frequent. To examine them thoroughly atropia should be applied, and lateral illumination used.

Circular posterior synechia exists if the margin of the entire pupil is adherent to the capsule of the crystalline lens; the area of the pupil may be free from effusion, or nearly so.

Total posterior synechia exists if the entire posterior surface of the iris is adherent to the capsule of the crystalline lens.

Synicesis of the pupil means closure of the pupil by a more or less opaque substance, which is continuous with the iris. This is a frequent result of iritis.

Changes in colour of the iris are observed throughout the course of iritis, and are one of its earliest symptoms. A blue iris appears greenish, and a brown one of a rust colour.

Large masses of lymph, or pus, or suppuration of the plastic material, give the iris a yellow appearance.

The "sclerotic redness" ("sclerotic zone," "ciliary redness") appears along the margin of the cornea. It varies from a hardly perceptible pink zone to a large crimson belt surrounding the cornea; in severe cases it is coupled with much conjunctival vascularity, and sometimes with chemosis.

The decrease of the sclerotic zone generally coincides with that of the iritis.

Other symptoms, which vary in degree, or which may be completely missing, are—loss of appetite, sleeplessness, pain, intolerance of light, "watering of the eye," with swelling and redness of the eyelids.

The pain is sometimes very severe, either in the eye, or forehead, or both; it may only be felt on touching the ciliary region, or may be intermittent or continuous. Leeches and atropia hardly ever fail to remove it.

The variations which occur in the course of iritis depend upon,—

(1.) The quantity of plastic material (the greater the quantity the more extensive the synechiæ, and the greater the structural changes of the iris).

(2.) The health of the patient. In those whose constitutions are much shaken, we may expect suppuration and subsequent atrophy of the iris.

(3.) The period at which we undertake the treatment.

(4.) And, lastly, upon the complications which arise from changes in other parts of the eye.

Simple iritis in an otherwise healthy person, and when of moderate degree, subsides in about four weeks. The sclerotic vascularity and the plastic material gradually disappear, the aqueous fluid and cornea become clear, and the colour of the iris and the mobility of the pupil (on discontinuing the use of atropia) more natural. Pigment spots upon the capsule of the lens, if not in contact with adhesions of iris, often disappear.

The changes in the structure of the iris depend upon the intensity, kind, and duration of the iritis; and also upon the number of attacks. Opaque patches and streaks upon the surface of the iris, together with changes in colour, alterations in mobility (from slight loss of contractility of some parts to complete immobility with Iridodonesis) may occur. The iris may lose all elasticity and become nearly transparent.

Complications.—Iritis is a frequent complication of morbid changes in the cornea. Deep ulcers, abscesses, or purulent corneitis, with or without hypopion, are, as a rule, accompanied by iritis, and sometimes by suppuration of the iris.

The local application of atropia, and still better iridectomy, frequently arrest the corneal changes.

Changes behind the iris.—Cyclitis is often present with iritis. Its presence may be assumed in every case of chronic iritis, if the tension of the eye becomes increased, and still more, if subsequently it sinks below par, and is accompauied by opacities in the vitreous chamber close behind the lens.

Simultaneous inflammation of the choroid, of the same kind as that of the iris, is equally common. With the ophthalmoscope we can often detect these changes during the height of iritis.

Treatment of Simple Iritis.

In every case, and at any stage of iritis, we should prescribe the local application of belladonna, or of atropia, to produce dilatation of the pupil.

(*a.*) To prevent as much as possible irregularities of the pupil and synechiæ.

(*b.*) To secure rest by preventing contraction of iris and ciliary muscle.

(*c.*) To alter the tension of the eye, and the circulation in the choroid.

In slight iritis the atropia should be applied from three to ten times daily; and if there is severe pain, every five minutes for some hours in the evening. These frequent applications are continued for from two to five days, or until pain and vascularity have become less.

The application twice daily is continued for from two to three weeks after all vascularity has subsided; by so doing a relapse or a fresh attack is less likely to occur.

The pupil in rare cases remains dilated for weeks, or acts but sluggishly long after the application of atropia has been discontinued; to remove this condition we apply calabar. (See Calabar and Atropia.)

Leeches (from two to six) are applied at bedtime to the skin of the corresponding temple, if the pain is severe and not soon relieved by atropia. Afterwards bleeding should be encouraged for one or two hours according to the general state of health. The eyelids must be kept closed for twenty-four hours after the application of the leeches.

Tepid water should be used to bathe the eyelids morning and night, or as often as may be agreeable.

Lotio Aluminis is ordered if there is purulent discharge.

The eyes may be used for work if no pain is caused by it, or if there

is no intolerance of light. Spectacles with blue-tinted glasses or a shade should be worn if there is intolerance of light. (See also Treatment of Syphilitic Iritis.)

Vision.—Impairment of vision is often the sole symptom for which advice is sought. Unfortunately several attacks of iritis may occur in the same eye, and permanently disturb the relations between the iris and crystalline lens without sensibly impairing vision. Neglect on the part of the patient in such a case prevents recovery without synechia. The impairment varies in degree. Only a slight "mist" may appear to intervene between the object and the eye, the patient being still able to attend to ordinary work. In severe cases there may be mere perception of light.

Vision, if atropia is employed in time, becomes "worse" by the pupil becoming dilated; and this symptom, though favourable, may frighten the patient, and induce him to forego the use of the atropia. We should warn the patient against this, and explain the object and effect of the remedy used.

The causes of impaired vision, if the iritis has completely subsided, must be sought,—

(1.) In the disturbed transparency of the cornea or pupil, or capsule of the crystalline lens.

(2.) In changes of the iris or ciliary muscle.

(3.) In complications arising from either the crystalline lens, vitreous substance, choroid, or retina.

(4.) And lastly, sometimes in orbital or cerebral disturbances.

If only one eye has been affected, we should use those medical, surgical, or optical means, which render this eye, as regards vision, as useful as possible. Thus, after the cessation of iritis, we may have occasion to treat corneal opacities, posterior synechiæ, closed pupil, cataract with closed pupil, impaired accommodation with undue hardness of an otherwise transparent crystalline lens, cyclitis, &c.

(1.) Adhesions of the iris to the crystalline lens (Posterior Synechiæ) impede the movements of the iris and crystalline lens, and interfere with accommodation. They give rise to astigmatism, and occasionally to troublesome polyopia.

Loss or great impairment of mobility of the iris is said to produce hemeralopia (from the inability of the pupil to dilate at dusk), and occasionally sympathetic irritation of the healthy fellow eye.

(2.) In children several rents (spontaneous artificial pupils) have been observed in the iris. These may be the results of adhesions opposing the growth and movements of the iris.

(3.) Pigment and opaque spots upon the capsule of the lens intercept or diffuse the light, and may give rise to intolerance of light, or to "muscæ." If occluding the pupil, they may reduce vision to mere perception of light.

The amount of light which can still be perceived (together with the power of indicating the direction from which the light is thrown upon the iris) may be the sole means of ascertaining the degree of sensibility of the different parts of the retina.

(4.) We often find, especially in total posterior synechia, portions or the whole of the anterior surface (fibrous part) of the iris, or, more rarely, the entire iris, pushed forwards or "bulged." The pupil appears drawn back while the bulging portions of iris sometimes touch the cornea; behind these fluid is accumulated. This condition must not be mistaken for displacement of the iris and crystalline lens towards the cornea, as is sometimes observed in cyclitis.

The "bulging" of the iris may be followed by glaucomatous changes, viz. increased tension of the eye; anæsthesia of the cornea; paralysis, at first of the peripheral parts of the retina, finally followed by loss of vision and cupping of the optic disc, &c. At a still latter period atrophic changes appear with decrease of tension, chalky cataract, and atrophy of the tunics, &c.

A few synechiæ interfere but little with vision; the application of atropia, continued for several months, causes them sometimes to become torn through. The synechiæ can, if desirable, be removed by corelysis.

If many synechiæ exist and interfere with vision, or, if they are the results of recurrent iritis, iridectomy with corelysis should be performed.

Synechiæ, with occlusion of the pupil, with or without bulging of the iris, often require the combination of iridectomy with removal of the crystalline lens, unless we succeed in removing the uvea from the capsule of the lens. In all cases we must be prepared to find uveal pigment adherent to the capsule; and always examine for it by lateral illumination. The non-removal of the uvea, together with the fibrous part of the iris, is a frequent cause of failure of iridectomy or of the operation for artificial pupil. By a thoroughly performed iridectomy communication is established between the aqueous chambers; and a favourable change frequently occurs in the nutrition of the choroid, retina, and vitreous substance.

No benefit is derived from any operation if the eye is soft, and vision so impaired that, e. g., a strong flame of gaslight held close to the eye is barely perceived, or only in certain directions. The operation of iridectomy may however be recommended, if the flame can be perceived at from six to ten feet from the eye, and if at the same time the peripheral parts of the retina are sensitive.

Leeches,

If ordered for the purpose of acting upon the eye, are applied to the skin of the corresponding temple.

Instillation of atropia increases their effect.

The eyes should be kept closed during the bleeding, and for some hours after it has ceased. Evening is the best time for the application of leeches.

The blood-vessels of the choroid (viewed with the ophthalmoscope during the application of leeches) at first become contracted, then dilated, then contracted again within their usual diameter, and finally dilated again to their normal calibre.

Application of pressure to the Eye. The "Pressure Bandage."

A bandage applied over the closed eyelids, when intended to produce pressure upon the eyeball, should not cause the sensation of tightness; while, at the same time, it should keep the eyelids immovable and smoothly expanded over the eye.

Mode of applying the bandage. A square piece of soft dry linen, sufficiently large to cover the eyelids, is laid upon the closed eyelids. Upon this small portions of cotton wool or wadding are placed; first into the space between the bridge of the nose and the eyeball, and then (this space being nearly filled up) into the sulcus between the eyeball and the upper margin of the orbit. Lastly, some is spread over the remainder of the piece of linen. Occasionally, while applying the wadding, the hand is gently pressed upon it, to see whether the eyeball can be felt more in one than in another part; if so, the distribution of wadding has to be changed until a resistance, equally elastic throughout, has been produced.

For very prominent eyeballs it may suffice to place wadding along the margin of the orbit only. A flannel bandage is finally applied over the wadding. The more firmly this bandage is applied the more pressure can be obtained.

Atropia and Calabar.

Among medical agents which are employed to act upon the iris we distinguish *Mydriatics*, or remedies which cause dilatation of the pupil and paralysis of the power of accommodation, and *Myotics*, which increase that power, i. e. the contraction of the ciliary muscle, and which cause contraction of the pupil. Of Mydriatics the preparations of Atropa Belladonna (Solaneæ) are in general use. As Myotics are used the preparations obtained from Physostigma venenosum (Leguminosæ).

The Sulphate of Atropia.—Wherever the term Atropia is used the solution of Sulphate of Atropia ($\frac{1}{4}$ of a grain of the Sulphate of Atropia to ℥i. of distilled water) is to be understood.

Atropia or "Atropine" is supposed to act as an excitant of the ganglion cells and the fibres of the sympathetic nerve. A solution of the Sulphate of Atropia, brought into contact with the conjunctiva, passes through the cornea, mixes with the aqueous humour, and produces dilata-

tion of the pupil. Such aqueous humour, applied to another person's conjunctiva or cornea, again produces dilatation of the pupil.

Profuse "watering of the eye," morbid changes of the cornea, and great increase in tension of the eyeball, may prevent the Atropia from reaching the iris.

The pupil of a healthy eye becomes dilated to its maximum (i. e. its sphincter is paralysed and its dilator strongly contracted) in from fifteen to thirty minutes after applying to the conjunctiva a solution of the Sulphate of Atropia (Atropiæ Sulphatis gr. $\frac{1}{4}$. Aquæ destillatæ ℥j). Soon after this the ciliary muscle, and with it the power of accommodation, becomes paralysed. Within about three hours after application its effects can, with the ophthalmoscope, be perceived in the retina and choroid; in these it causes dilatation of the blood-vessels. It also affects the action of the external muscles of the eye. Its effect continues for several days after one application. By paralysing the ciliary muscle it is supposed to contribute towards diminution of the tension of the eyeball.

The stimulus of light, efforts of accommodation, &c., sometimes act injuriously when the blood-vessels of the interior of the eye are dilated by Atropia.

Atropia reaches the throat by passing through the lachrymal passages, and, if frequently applied, may, especially in children, cause symptoms of poisoning. Such symptoms are increased rapidity of the pulse, e. g. 110 pulsations instead of 70, with dryness of the throat and restlessness, followed by sleep with much dreaming. Graver symptoms are general excitement, with hallucinations ("strange figures and objects seeming to move about on the bed"), and inability to swallow. In cases of iritis of one eye only and in cases of spasm of the ciliary muscle, symptoms of poisoning may appear before any local effect upon the iris or accommodation is produced. Our attention should be directed to the above symptoms if prolonged application of Atropia is required.

The best antidote, if the graver symptoms present themselves, is the subcutaneous injection of the Acetate of Morphia, which produces its effects in from ten to twenty minutes after injection.

The Sulphate of Atropia is prescribed in the form of, (1.) *Drops* of varying strength (*Guttæ Atropiæ*). Two kinds are in general use—

(*a.*) ℞ Atropiæ Sulphatis gr. $\frac{1}{4}$, ad aquæ destillatæ ℥i. Misce (to be used in inflammatory changes, corneitis, iritis, &c.). (*b.*) ℞ Atropiæ Sulphatis gr. ij. Aquæ destillatæ ℥j. Misce (to be used to bring on rapid paralysis of the power of accommodation).

The effect of the Atropia is best secured by giving directions "to take a camel's-hair brush or the fan of a quill, to dip it into the lotion, then gently to draw the lower lid away from the eye and to touch the inner surface lightly with the brush. The mere touching of the conjunctiva with

the brush suffices. The Sulphate of Atropia should be pure, and contain no resinous substances: it should cause no irritation. One part of the Sulphate of Atropia to two thousand parts of distilled water is sufficient to dilate the pupil.

If for ophthalmoscopic purposes we wish to dilate the pupil without impairing the accommodation too much, we may use a lotion made of one part of Atropia to one hundred and twenty parts of water.

If the drops are used frequently or for a considerable time (in some patients even after one application), increased redness of the conjunctiva with chemosis and muco-purulent discharge, with swelling of the eyelids, and sometimes erysipelas on that side of the face, may appear. This form of inflammation caused by Atropia is termed *atropinism*. The Atropia must, in such cases, be discontinued for a few days, and some astringent lotion (of Acetate of Lead or of Alum) be used. In such cases, instead of using the drops, we apply the Atropia gelatine.

(2.) Unguentum Atropiæ = ℞ Atropiæ Sulphatis gr. i. Unguenti Spermaceti ℥ii. Misce.

(3.) Endermatic application of Atropia.

A blister is raised over the spot beneath which lies the nerve which we wish to act upon by Atropia. The skin of the blister being removed, from $\frac{1}{12}$ to $\frac{1}{4}$ of a grain of the powdered Sulphate of Atropia is sprinkled over the raw surface.

(4.) Subcutaneous injection of Atropia.

An injection of $\frac{1}{60}$ of a grain of the Sulphate of Atropia produces acceleration of the pulse. As much as $\frac{1}{12}$ of a grain has been injected at one time.

(5.) Atropia gelatine.

The pieces of Atropia gelatine supplied by Messrs Allen and Hanbury, of Plough Court, Lombard Street, E.C., London, are divided into little squares. Each square contains (according to an examination made by Mr Dan. Hanbury) somewhat more than $\frac{1}{1000}$ of a grain of the Sulphate of Atropia.

When brought into contact with the conjunctiva the Atropia gelatine becomes rapidly dissolved; it does not, like Atropia paper, act as a foreign body.

Physostigma venenosum.

The fruit of this plant is a bean, termed the Calabar bean. (Wherever the term "Calabar" is used a preparation of the Calabar bean is to be understood.)

The alcoholic extract of the bean known as the extract of "Calabar bean" and the Calabar gelatine are the preparations generally used.

Calabar, when brought into contact with the conjunctiva, causes lachry-

mation, and in about five minutes later contraction of the pupil, followed by contraction of the ciliary muscle. This contraction reaches its height in half an hour, and continues for about twelve hours, without however producing complete immobility of the pupil.

Calabar counteracts the effect of atropia, and also acts if there is paralysis of the pupil. The contraction of the pupil and ciliary muscle, thus produced, generally causes pain, which may be very severe, and continue for hours. The pain increases if the eye is used, i. e. if efforts at accommodation are made. Slight efforts at accommodation produce much more contraction of the ciliary muscle if a weak solution of the Calabar has been applied, than if the same efforts are made under ordinary circumstances.

Patients, if directed to apply the Calabar themselves, should use small squares of Calabar gelatine (as prepared by Allen and Hanbury), which contain a known quantity of the active principle of the bean.

An examination of Calabar gelatine (made by Mr Dan. Hanbury) shows that "500 of the little squares weigh 9.75 grains, say in round numbers 10 grains. This allows for one square a weight of ·02 grain, or $\frac{1}{50}$ of a grain. Then, as the gelatine contains *one-sixth* of its weight of Extract of Calabar bean, a little square, which weighs ·02 grain will contain of it (the extract) ·0033 grain ($= \frac{1}{300}$ of a grain).

A square of the Calabar gelatine placed on the conjunctiva of the lower lid readily dissolves. Its local effect ceases in from twelve to twenty-four hours. Atropia applied to one eye and "Calabar" to the other produce their specific effects, and do not interfere with each other's action.

Calabar taken internally depresses the functions of the spinal cord, and thus prevents the transmission of nervous impulses through the cord to and from the iris.

Calabar is by some looked upon as a respiratory poison causing asphyxia, by others as interfering with the contractions of the heart and producing syncope.

Syphilitic Iritis and Syphilitic Changes of the Structures behind the Iris.

SYPHILITIC IRITIS.

This form of iritis is frequently confined to circumscribed portions of the iris. The pupil is contracted, generally irregular, and acts sluggishly. The inflamed portions of iris appear swollen, reddish, and soon become covered with the characteristic yellowish, or reddish, or brown nodules termed "lymph-nodules." These, when examined quite fresh, consist of

closely-packed connective tissue corpuscles (?), enlarged capillaries, new vessels, and deep brown or black pigment granules.

The lymph nodules may fill the area of the pupil, and in severe cases obscure the greater part of the iris; they may touch the cornea or sclerotic, and give rise to infiltration and perforation of these tunics. They may undergo suppuration and destroy the entire iris. They disappear gradually; their place becomes occupied by grey opaque tissue, which in its turn may become "absorbed."

Beyond this peculiar stage the iritis does not present any features characteristic of syphilis, although the existence of posterior synechiæ, together with contracted and irregular pupil, should always make us treat it as such.

This form of iritis is most common between the ages of twenty and forty, but it not unfrequently occurs in infants between the ages of two months and one year. In these as well as in adults we rarely fail to discover other syphilitic symptoms.

Syphilitic iritis, especially if the first attack has been a severe one, often recurs, and sometimes with remarkable periodicity, though it is rare during any of the subsequent attacks to meet with the characteristic "lymph nodules."

The usual absence of redness of the eyelids, and the slight sclerotic vascularity, often cause iritis to be overlooked by the patient when confined to one eye. (See Simple Iritis.)

Treatment.

Mercury.—A small quantity (about the size of a large pea) of the Unguent. Hydrarg. Nitrat. Mitius is rubbed into the skin of the forehead at bed-time, until all undue vascularity of the eye has disappeared. The use of the ointment is discontinued if the gums should become affected.

For infants we prescribe one grain of the Hydrarg. c. cretâ, to be given daily for from five to ten days.

The Iodide of Potassium should be given in doses of from three to five grains twice daily, in half an ounce of Decoctio Sarzæ, until all ciliary redness has subsided.

Some recommend from one-sixth to one-third of a grain of Morphia, at bed-time, after the bowels have acted.

Turpentine (in five-grain doses three or four times daily) has been found of use in weak persons suffering from frequent attacks of iritis, and in chronic iritis of so-called rheumatic character, with much sclerotic and subconjunctival vascularity.

The local treatment is that of simple iritis.

Iridectomy.—No benefit is derived from this operation in simple, nor in syphilitic iritis, nor in corneo-iritis as long as fresh plastic material or

lymph makes its appearance ; the new pupil becomes closed again with plastic exudation.

Some describe a *Gonorrhœal Iritis,* the peculiarities of which are stated to be, excessive pain, intolerance of light with profuse flow of tears and dusky sclerotic redness, the iritis being preceded by gonorrhœa, with effusion into the joints. Mercury and Atropia were found of no use.

SYPHILITIC CHANGES IN THE STRUCTURES BEHIND THE IRIS.

If a person shows symptoms of syphilis, e. g. in the skin, or in the cornea, or iris of one eye, and complains of impairment of vision of the externally healthy fellow eye, we often discover syphilitic changes in the deeper structures of the other eye. These changes are in most cases characteristic of syphilis.

It is usual in inherited as well as in secondary syphilitic inflammation of the deeper structures, to find several of these structures inflamed simultaneously. The name by which the inflammation is described is derived from the structure which appears most altered. Thus we speak of syphilitic Choroiditis; Choroido-iritis; Retinitis, &c., though the vitreous, or lens, or sclerotic, &c., may participate in the same inflammatory changes.

From this point of view we meet in order of frequency with—

(1.) Choroiditis (of which the Choroiditis disseminata is one form).

(2.) Inflammation of the optic disc and of the choroid and retina immediately adjoining.

(3.) Inflammation of the vitreous substance.

The nature and degree of impairment of vision existing during these different forms of specific inflammation vary. In many cases, it is impossible, as long as complications with corneitis or iritis exist, to decide as to the share which the changes in the deeper structures take in the impairment.

As rarer changes, observed in patients suffering from syphilis, should be mentioned — (*a.*) Rather sudden decrease in the size of one eyeball, with signs of choroiditis, and with a marked decrease in the number of the retinal vessels. (*b.*) Rapid increase in the size of one or of both eyeballs. (*c.*) Ciliary staphyloma with glaucoma. (*d.*) Circumscribed cyclitis. (*e.*) Anæmia of the outer half of the optic disc of both eyes after sudden impairment of vision.

Pathology of (nine) eyeballs removed from patients who suffered from syphilis at the time of operation.

In four eyeballs atrophic changes were found in the choroid, as observed after choroiditis. In one, large lymph nodules were found simultaneously.

Five of the eyeballs belonged to patients suffering from secondary syphilis, and four to persons with inherited syphilis.

Three of the former eyeballs presented the changes observed in ophthalmitis (in two these changes appeared spontaneously, and in one during chancre of the sclerotic and eyelids).

In one eyeball (after repeated attacks of iritis) an attack of choroiditis occurred. This was followed by circumscribed staphyloma of the tunics in front, and beneath the insertion of the superior rectus muscle, with severe pain and loss of vision by glaucoma. In another eye (which was blind, slightly shrunken, and soft, and which was excised on account of great pain) blood was found in the vitreous chamber with extensive atrophy of numerous portions of the choroid and retina, as observed after choroiditis "disseminata."

Of the four eyeballs belonging to patients suffering from inherited syphilis, one was removed during an attack of choroido-iritis. The cornea in three was found opaque, and the iris adherent to it (total anterior synechia). The synechia probably was the result of prolonged contact between the swollen and inflamed iris and cornea.

The crystalline lens, the capsule of which was adherent to opaque deposit in the pupil, had a hard and semitransparent nucleus in the four eyes (the age of the eldest of the patients was 27 years). The vitreous substance was yellowish in all the four eyes. It was semifluid in two, and fluid in two. In one of the latter it was mixed with numerous clots of blood, some of which were attached to the ciliary processes, and some to the retina along the ora serrata.

The results of dissection of the choroids, retinæ, and optic discs of these eyeballs are given under "inflammation of the optic disc and of the adjoining choroid and retina."

Syphilitic Inflammation of the Vitreous Substance.

This inflammation has been observed in one eye alone as well as in both eyes simultaneously; it can only be recognized with the ophthalmoscope. The optic disc, retina, and choroid appear uniformly hazy throughout (as represented in Plate VI. Fig. 11, to the left of the optic disc).

During the height of the inflammation we find (either on direct ophthalmoscopic examination, or by means of focal light) very minute numerous white and opaque dots throughout the vitreous chamber. These dots appear slightly movable during movements of the eyeball. They disappear under proper treatment, and are attributed to a temporary loss of transparency of portions of the vitreous substance.

Vision improves rapidly under mercurial treatment; in several cases it has done so from mere perception of light to enabling the patients to read and attend to work.

Attacks of the same form of inflammation may occur at intervals of several years. They may appear without outward signs of inflammation and without pain.

Patients complain of a mist (coming over the sight rather suddenly), which increases rapidly in density; in order to recognize objects, they are obliged to look for some time. Sometimes the mist becomes "too thick" even to recognize objects.

The sensibility of the retina is impaired throughout, but proportionately from its centre towards its periphery.

The treatment locally consists in the application of Atropia (as in iritis); and generally in the use of mercury, of which the bichloride in doses of $\frac{1}{20}$ or of $\frac{1}{16}$ of a grain, has been found most effectual. The treatment is continued until a good view can be obtained of the optic disc.

Besides the peculiar opacities observed during the inflammation just described, we often meet with opaque shreds in the vitreous during, and after, choroiditis or retinitis. The shreds are readily seen with the ophthalmoscope, and also by the patient, if they are close to a sensitive part of the retina. Those which occur in large numbers close behind the crystalline lens are particularly conspicuous in consequence of their admitting but a small quantity of light into the eye.

Syphilitic Inflammation of the Optic Disc and of the adjoining Choroid and Retina.

The centre of the optic disc (at the height of the inflammation) appears pink, the remainder swollen, grey, opaque, and ill-defined. The contours of the optic disc shade off into those of the inflamed choroid and retina, which, in their turn, gradually pass into the healthy retina and choroid. Choroiditis disseminata often occurs simultaneously.

The retinal blood-vessels appear much less numerous; they are thin in the pink central part of the optic disc, and more or less indistinct in the swollen, grey, opaque portions; the veins in the retina are unequally dilated.

In some cases we find extreme anæmia of the optic disc and retina, only one or two thin blood-vessels passing through the swollen optic disc into the retina.

Opaque flocculi in the vitreous adjoining the inflamed parts occur in most cases.

The inflammation at this stage may be mistaken for that observed during albuminuria, or for that which accompanies tumours at the base of the brain. This last kind of inflammation is characterized by the turgid state of the retinal veins in the disc as well as in the retina, and by the

swelling being confined to the optic disc. Inflammation of the optic disc during albuminuria is accompanied by brilliant yellowish patches, which appear in the infiltration round the optic disc and in the region of the yellow spot, together with blood-spots.

The optic disc (in the farther course of the inflammation) gradually becomes more defined, more anæmic, and somewhat smaller.

In some cases it retains a pale pink colour; in others it becomes greyish-white (resembling the optic disc in Plate X. Fig. 35), or of a brilliant white colour.

Simultaneously with the farther changes in the optic disc we find the vitreous, retina, and choroid becoming more transparent; portions of the retina may retain a semiopaque colour for years.

Signs of atrophy gradually appear in the choroid near the optic disc in the form of pigment spots and transparent patches. This in young persons is often accompanied by thinning of the sclerotic, bulging of the tunics, and elongation of the eyeball. The inflammation frequently occurs in both eyes, sometimes with iritis in one or both.

Vision.—At the commencement of the inflammation patients occasionally complain of intolerance of light with pain when using the eyes; of fiery stars, &c. (from hyperæmia of the optic nerve); or of a "mist" before the eyes, or of "small" black spots; or of a black web floating before the eyes, obscuring sight in certain directions (caused by opacities in the vitreous close to the retina). These symptoms may disappear rapidly; or may be followed by occasional sudden loss of sight; or by inability to distinguish small or distant objects.

The slightest pressure upon the eyeball is sometimes followed by complete loss of vision for several minutes.

The prognosis, as regards vision, depends much upon the stage of the inflammation at which we undertake the treatment of the case. It is more favourable if lymph and other morbid products have not yet undergone secondary changes nor induced atrophy.

No improvement of vision has been obtained in those cases in which the optic disc has been anæmic (bluish-white) with atrophic patches in the choroid.

Pathology.—The following pathological conditions have been found on dissection of eyes removed from syphilitic persons.

The optic disc in one case, in which profuse hæmorrhage had occurred into the vitreous chamber, was deeply cupped; the deepest part of the cup was level with the outer edge of the sclerotic aperture; and the few vessels which passed through the cup were extremely thin.

In three cases the optic discs, with the adjoining retinæ and choroids,

resembled the one represented in Plate VI. Fig. 11; a thick layer of healthy optic nerve fibres in each case could be recognized passing from the disc over the retina. The disc was cupped, but the cup was confined to the middle of the disc, i. e. to the transparent fibrous portion which surrounds the vessels.

The ill-defined outline of the optic disc was found to be the result of morbid changes in the adjoining choroid and retina.

The blood-vessels were scarce, very thin, and unequally dilated; large portions of retina were in a state of atrophy.

The loss of vision, in the three cases, was explained by the morbid changes in the retina, which in their turn were in a great measure caused by those in the choroid.

The structure of the retina, when examined by the microscope, appeared healthy wherever the subjacent choroid was normal. "The retina" was firmly adherent to the transparent atrophic patches of choroid as also to some of the pigmented ones. More especially over and near the spots where the hexagonal epithelium had been disturbed the retina was found semiopaque, and sprinkled with yellow, or greyish-white opaque dots. The yellow dots (microscopically) consisted of clusters of oil globules, the grey and opaque ones of a powdery substance (altered cells of the granular layers).

Among and upon these dots were groups of brown pigment granules, which (when viewed with the naked eye) appeared as minute black and brown grains in the retina.

The rods and bulbs were destroyed wherever the granules of the hexagonal epithelium had disappeared; they were displaced, or distorted where the arrangement of the granules of the hexagonal epithelium was disturbed. The fibres of the framework (connective tissue) of the retina were much disturbed, and appeared interlaced with webs of slender filaments; which, probably, had become developed out of lymph. (See Plate III. Figs. 2, 3.)

The ganglion cells and granules of the retina could be recognized in many places where the rods had been destroyed; while in others the granules had disappeared, and on section large irregular lacunæ were observed among the connective tissue intervening between the layers of optic nerve fibres and the choroid.

The layer of optic nerve fibres could everywhere be recognized, even in those places where the retina was adherent to transparent atrophic portions of choroid, and where none of the retinal elements, except the connective tissue, could be recognized.

SYPHILITIC CHOROIDITIS.

The choroiditis may extend over a large *continuous* area (see Plate X. Fig. 36), or may appear in numerous *separate* spots (see Plate VI. Figs. 10, 11). In the latter form we observe in the choroid, during the height of the inflammation, yellowish or white and opaque somewhat ill-defined spots (nodules) or groups of spots.

The nodules of lymph (as represented in Fig. 10) resembled (in one case in which they were examined microscopically) those taken from the iris (in syphilitic iritis), and consisted of closely packed caudate cells. Such become developed into fibres.

Some of the nodules surround large choroidal veins, but the greater number are seated among and upon capillaries of the choroid.

In many places the elastic lamina is destroyed; and the roundish nodules can be seen projecting from the choroid into the retina, in some places reaching as far as the inner membrana limitans.

The displacement of the retinal elements is particularly well seen in sections. In one of the eyes mentioned above a narrow strip of retina was displaced from the choroid by an unusually prominent nodule of lymph which was about the size of a small pea, and which was situated near the ora serrata. The strip, about one-fifth of an inch wide, extended from the top of the nodule at the ora serrata, as far back as the equatorial region.

The lymph nodules occur as often round the optic disc as in the equatorial region. They may be missing, or may have undergone secondary changes when we see the patient for the first time.

The inflamed choroid loses its transparency. Morbid changes in adjoining parts, especially opacities in the vitreous, are usual complications. They are most conspicuous if the inflammation is severe in the ciliary region of the choroid (cyclitis).

If the optic disc is implicated (*neuritis with choroido-retinitis*) we find the disc ill-defined (see Plate VI. Fig. 11, and Plate X. Fig. 36), and the adjoining retina opaque, and more or less anæmic. The optic nerve fibres may become destroyed if the inflammation is severe.

In Plate X. Fig. 36, the optic disc and the adjoining tunics can barely be recognized. The opacities in the vitreous chamber and the semiopaque inflamed tunics (the vessels of which are masked or obliterated, as often occurs in choroido-retinitis) render an illumination of these parts difficult.

Pain in and round the eye, intolerance of light and "watering," sclerotic vascularity with iritis, are frequent complications. These symptoms may however be entirely missing, especially if the inflammation is confined to that part of the choroid which corresponds to the retina.

Vision becomes impaired rather suddenly. Patients generally complain of a mist intervening between objects and "the eye."

Opacities in the vitreous, implications of retina, changes in the optic disc, iris, &c., are so many sources of impaired vision. Patients readily observe the impairment if both eyes are affected, or if the retina in the region of the yellow spot is implicated.

When portions of retina of the latter region are encroached upon by nodules of lymph, or by products of inflammation, we often hear patients state that parts of an object, or letters of a word appear missing, and that, to see them, the eye or the object has to be moved in certain directions. The transition from these to more sensitive parts of the retina is rather sudden.

Flashes of light, fiery circles, &c., are often complained of if congestion of the optic nerve accompanies the inflammation, and more frequently during the commencement, and again when atrophic changes set in.

A cloud, or clouds, or black spots, or a black web, "moving before the eye" may be the result of opacities in the vitreous chamber close to the surface of the retina. Such symptoms often disappear rapidly under proper treatment.

The lymph nodules, like those in iritis, disappear in from three to ten days; in their place we find patches of pigment upon vascular or more or less anæmic portions of choroid.

The inflammatory changes, which are characterized by *uniform turbid red colour* of the affected choroid and retina, take a more chronic course, and the choroid recovers its transparency gradually. Pigment spots appear in and upon the choroid, among yellow and white spots; these not unfrequently are accompanied by one or several staphylomata "of the sclerotic." The outline of the optic disc and the blood-vessels of the retina become more defined.

Some anæmia of the retina, with impaired transparency of some parts, and with the outline of the optic disc somewhat ill-defined, continues long after the active inflammation has subsided.

The pigment spots.—Those which are caused by groups of stellate pigment cells of the choroid have a more or less deep brown colour, and are placed between the veins of the choroid; they are, as regards shape, represented in Plate VIII. Figs. 19, 23. Many of these groups, in the course of choroiditis, become more intensified in colour, and are very conspicuous in an anæmic choroid. This is particularly the case beneath, and round black pigment patches, and round atrophic portions of choroid.

The black spots.—Upon the groups of stellate pigment cells we often meet with black or deep brown spots, circles, or patches. These consist chiefly of granules of the hexagonal cells which have become black or deep

brown. These spots are seated upon the choroid, or in the retina, into which they become displaced during inflammation.

Their shape probably depends upon that of the inflammatory products which may have disturbed their natural position.

The round and the crescentic-shaped ones are prevalent.

The white patches are the results of destruction of pigment of the choroid (viz. of the stellate pigment cells) with obliteration or destruction of the blood-vessels. A transparent atrophic tissue remains, which, being in contact with the white and opaque inner surface of the sclerotic, appears as a white patch. The white patches are, as a rule, surrounded by less atrophic portions.

SEROUS IRITIS.

This form of iritis generally occurs in young or middle-aged persons. It appears suddenly, with more or less irregular dilatation of the pupil, and with increased tension of the eyeball. The iris at the height of inflammation is highly hyperæmic and discoloured, with little or no plastic exudation.

The anterior chamber appears enlarged by increased quantity of more or less turbid aqueous humour. If there is opacity of the cornea, it is either diffused or assumes the form of minute opaque dots, many of which disappear after escape of the aqueous humour. The ciliary region is unduly vascular, and the tension of the eyeball above par.

The intolerance of light and the flow of tears (of the "non-inflamed eye") also are often great.

Severe pain is complained of in the inflamed eye, and over the corresponding side of the head.

The optic disc and the other tunics, examined with the ophthalmoscope at the height of inflammation, either present an appearance as represented in Plate X. Fig. 36, or are hidden from view by opaque substance in the vitreous chamber.

The iritis subsides gradually within about two months; and, owing to morbid changes in the deeper tunics, is often followed by softening and shrinking of the eyeball, with complete loss of vision.

The probable cause of this form of inflammation is the sudden appearance of some foreign substance, such as clots of blood, an entozoon, &c., in the ciliary region, or in some other part of the interior of the eyeball.

Treatment.

Great relief follows the application of from four to six leeches to the skin of the temple next the "inflamed eye," with frequent application of

Atropia or of Lotio Belladonnæ to the inflamed eye; or to both eyes if no amelioration is obtained within 36 hours. No leeches should be ordered if the pain is slight.

No benefit has been derived from general medical treatment, nor from iridectomy during the height of iritis.

The prognosis is unfavourable, on account of the deep-seated changes which often lead to shrinking of the eye.

SYMPATHETIC IRITIS AND OTHER SYMPATHETIC CHANGES.

A series of morbid changes are termed *sympathetic*, on account of their occasionally appearing in one eye, subsequent to traumatic, or spontaneous inflammation of the fellow eye.

The following, in order of frequency, seem to be the usual causes of such changes:—(*a.*) Injury to one eye, implicating the ciliary muscle and the ciliary processes; or the presence of a foreign body lodged in the eye, and more particularly in the ciliary region. The injured eye may be inflamed, suppurating, glaucomatous, staphylomatous, or even shrinking when the sympathetic changes appear in the fellow eye.

(*b.*) Dislocation of the crystalline lens (e. g. depression).

(*c.*) Choroiditis, followed by chalky deposit among the ciliary processes.

These sympathetic changes are tabulated under the following heads, viz.: sympathetic irritation, sympathetic inflammation, and sympathetic amblyopia or amaurosis.

One or several of these may appear in the non-injured eye simultaneously with the changes in the injured eye, or at the height of its inflammation, or even long after all apparent morbid action has ceased.

Sympathetic Irritation.

The symptoms are, pain in the ciliary region, often only felt when touching that part; also pain in the forehead of the corresponding side, which is rarely continuous, but always appears when looking steadily at an object. There is increased flow of tears, and undue vascularity of the conjunctiva, especially in the ciliary region.

Vision, as to acuteness, is normal, but there is more or less asthenopia.

Removal of the injured eye, as a rule, arrests the sympathetic irritation of the fellow eye immediately, or within a few days.

The patient, as long as the injured eye or the cause of the sympathetic irritation has not been removed, must thoroughly rest the eyes; out of doors wear a shade and spectacles with tinted glasses, and use Atropia twice daily to both eyes.

Sympathetic Inflammation.

The inflammation in most cases commences with what is termed sympathetic iritis, and in many it goes on to chronic ophthalmitis.

SYMPATHETIC IRITIS.

Sympathetic iritis is a peculiar, and fortunately rare, form of iritis.

It has been observed after concussion of the eyeball, and after some foreign substance has become lodged in one eye. It appears first in the injured eye, and soon after affects the sound one; or the injured eye may have become destroyed at the time when the iritis sets in in the fellow eye.

The iritis commences without pain, with moderate intolerance of light and slight undue vascularity of the sclerotic. It thus escapes notice on the part of the patient; and if confined to one eye may, together with the deep-seated changes, have already caused shrinking of the eyeball before it attracts attention.

At first there is slightly increased tension of the eyeball: this is gradually followed by abnormal decrease of tension. The aqueous humour is somewhat turbid, the pupil fixed and contracted, or of medium size, with often total posterior synechia.

The iris is swollen, discoloured, and crowded with large varicose blood-vessels; sometimes in such numbers that its texture seems changed into a close network of enlarged vessels.

There is slight sclerotic redness, and some enlargement of the ciliary veins.

It must be borne in mind that in most cases the choroid and vitreous substance become similarly affected. (See Sympathetic Ophthalmitis.)

When examining the uninjured eye with the ophthalmoscope, before any iritis is perceptible and while vision is still acute, we find the optic disc pink; some diminution in the width of the retinal arteries, along with enlargement and varicosity of the retinal veins. We may still be able to view the retina, &c., after iritis has set in; we then find (if the iritis has existed from four to six weeks) the optic disc pink, ill-defined, the retinal vessels few and thin, and only traceable a short distance into the retina. The latter, together with the choroid, has a uniform hazy, dirty-red colour.

Vision gradually becomes misty, and is in many cases lost in both eyes. The eyeballs become reduced to small soft "stumps."

Treatment.

Medical treatment has hitherto been found useless. The removal of the injured eye should be urged at once if vision is destroyed, or if symptoms of sympathetic inflammation appear in the other eye, though vision of the injured eye may not be quite lost. Excision of the injured eye

should likewise be recommended if the symptoms of sympathetic irritation do not subside on proper treatment; such as the application of warm fomentations,—the frequent application of Atropia,—the wearing, when out of doors, of spectacles with tinted glasses,—and confinement in a darkened room when at home, as long as there is the slightest intolerance of light,—with complete rest of the eyes for months after all vascularity has disappeared.

In two cases (admitted into the hospital within the last two years) in which the varicose state of the vessels of the iris existed already in both eyes, useful vision and normal tension were restored to both eyeballs, by performing iridectomy, with removal of some of the ciliary processes adjoining the excised iris; and by subsequently removing the crystalline lens, which previously had been rendered opaque.

This treatment was adopted upon the supposition that the crystalline lens acted as a foreign body; and with the wish to interrupt the circle of infiltrated ciliary processes.

The excision of the injured eye, though there may be no sign of disturbance in the sound one at the time of the operation, unfortunately does not exclude the subsequent occurrence of the sympathetic inflammation.

Sympathetic Ophthalmitis.

If, as happens frequently, the changes observed in sympathetic iritis occur simultaneously in the choroid, and in the parts adjoining it, then the inflammation is termed sympathetic ophthalmitis.

This differs from common suppurative ophthalmitis by the chemosis, the swelling of the eyelids, and the pain being but slight, and by there being no abscess within the eye.

In sympathetic ophthalmitis we find the tunics, especially the choroid, retina, and the vitreous substance, saturated with a nearly transparent highly coagulable substance, termed by some fibrinous infiltration. At first there is slight swelling of the parts in which this substance appears; this is followed in the majority of cases by more or less shrinking of the eyeball. A section of an eyeball thus inflamed very much presents at one stage an appearance as if all the parts within the sclerotic were occupied by semiopaque cancerous growth. The infiltration is so uniform that the boundary between sclerotic choroid, retina, and vitreous cannot be traced, or only with difficulty. The semitransparent "infiltration" gradually changes into opaque tissue. A section made of such an irregularly-shrunken eyeball shows the parts within the sclerotic changed into a mass of bluish-white, and opaque dense fibrous tissue.

Shrunken eyeballs, when resulting from concussion, or foreign bodies lodged within the eye, are apt to become inflamed or painful, especially in

persons advanced in life; while eyeballs lost by sympathetic ophthalmitis remain quiet.

The treatment of this form of ophthalmitis is the same as that of sympathetic iritis.

Sympathetic Amaurosis, or Amblyopia.

The exterior of the affected eye generally presents no morbid changes, except impaired mobility of the pupil; whereas examination with the ophthalmoscope shows more or less anæmia of the retina and optic disc, with varying degrees of atrophy. These changes, in some cases, may be the results of chronic choroiditis.

The anæmia often appears first in the part of the optic disc nearest the yellow spot, and thence extends. Vision may remain "good" for months, or even years after the injury to the fellow eye, before it begins to fail "gradually."

Only in a few cases has some benefit been derived from the alternate use of strychnia and bichloride of Mercury.

CYCLITIS, OR INFLAMMATION OF THE CILIARY REGION OF THE CHOROID.

There are probably as many forms of cyclitis as of iritis. Dissections of eyes excised from the living, and observations on the fellow eyes to those excised (which have suffered from a minor degree of the same form of inflammation), have assisted in establishing the existence of *a simple or plastic cyclitis, and a syphilitic cyclitis.*

Plastic Cyclitis.

Plastic cyclitis frequently occurs after injuries (foreign bodies lodged in the eye, dislocation, swelling, &c., of the crystalline lens, depression of cataract). The cyclitis is the usual complication and often the cause of severe iritis or choroido-iritis; it is the cause of the chronicity of their course. Cyclitis often causes permanent impairment or loss of vision. The choroid in the ciliary region is destroyed, or is impeded in its functions by a more or less thick and extensive grey and opaque fibrous substance which intervenes between it and the crystalline lens and vitreous chamber. The nutrition of the vitreous substance and of other structures suffers. The eyeball becomes softer, the cornea opaque and smaller, the pupil closed. The tunics of the ciliary region gradually shrink, though the retina may continue sensitive for a long time. The retina frequently becomes drawn away from the choroid during contraction of the altered vitreous substance.

When using the term "fibrous substance" for the opaque texture found after cyclitis adhering to the inner surface of the ciliary processes and to the hyaloid fossa, it must be understood that this substance consists of "organized" portions of a plastic "effusion" mixed up with the structure of the ciliary processes, vitreous substance, &c.

Symptoms.

Pain, when touching that part of the sclerotic which corresponds to the "inflamed" portion of the ciliary processes, &c., is the most constant symptom of this form of cyclitis. The pain may be extreme and continuous in the eye; and in the head there may be none. It is attributed to displacement of and pressure upon the ciliary nerves.

More or less severe sclerotic and subconjunctival vascularity along the margin of the cornea, with enlargement and tortuosity of the veins of the iris, choroid, and retina. This having existed for some days, hypopion may appear and disappear repeatedly. At the same time yellowish and opaque shreds become visible behind the crystalline lens in the vitreous chamber. These and the hypopion, if there is no corneitis or iritis, are characteristic of cyclitis.

The hypopion may be absent, or caused by corneo-iritis; whilst the "vitreous opacities" are always found. The opacities may disappear in from four to six weeks; while grey and opaque fibrous and chalky spots make their appearance among and upon the ciliary processes and in the hyaloid fossa, together with the changes which follow inflammation of the other tunics.

Whether, subsequent to cyclitis, the eye shrinks or remains softer; or, having been so, resumes its normal tension, depends:

(1.) Upon the severity of the cyclitis.

The more of the ciliary region of the choroid is destroyed, or the thicker the fibrous substance is upon and among the ciliary processes and in the hyaloid fossa, the less favourable is the result.

(2.) Upon the state of health.

The same degree of cyclitis which in a poor ill-fed person leads to shrinking of the eye, may in a strong patient end in recovery of useful vision.

(3.) Upon the cause.

Foreign substances in the eye—a piece of metal, a dislocated lens—may become a continuous source of irritation, and of repeated attacks of cyclitis.

Vision.

On account of frequent complications with corneo-iritis or choroido-iritis it is difficult to determine the share which cyclitis takes in the im-

pairment of vision. The opacities in the vitreous chamber give rise to the complaint of a "mist" intervening between the eyes and the objects looked at.

The usual cause of loss of vision is displacement or atrophy of the retina, or both.

Treatment.

The treatment of cyclitis is the same as that of simple iritis. Leeches (from four to eight) are applied at bed-time if the pain is great. Applications of iced water should be tried at first, and continued as long as cold is pleasant.

The fellow eye must be kept at rest, and under the influence of Atropia if any sympathetic irritation exists.

Excision of the inflamed eye is performed if a "foreign body," e. g. a dislocated crystalline lens, is within the eye (attempts to extract it having failed), or if the shrinking blind eye is very painful.

Syphilitic Cyclitis.

This form of cyclitis is a sign of severe syphilitic inflammation: it is not unfrequent, and often occurs in both eyes.

Lymph sometimes not only appears among the ciliary processes, but also in the sclerotic along the margin of the cornea. Corneo-iritis and choroido-iritis occur simultaneously.

The cyclitis is observed in inherited as well as in secondary syphilis; in both, though especially in the former, it gives rise to staphyloma of the sclerotic, to thinning of the structures of the ciliary region, and to the peculiar sugar-loaf shape of the eyeball, with or without staphylomata.

Its effects upon the nutrition of the tunics are similar to those of simple cyclitis, though better recoveries are observed in the syphilitic form. Cases of shrinking of the eye with loss of vision unfortunately often occur. (For treatment, see Syphilitic Iritis and Staphyloma.)

HYPERÆMIA OF THE CHOROID.

Hyperæmia of the choroid gives rise to a sensation of fulness in the eye, and to slight lachrymation and intolerance of light, with pain in the eye.

When comparing the hyperæmic choroid with that of the healthy eye, e. g. in myopic persons (who are frequently subject to it), we observe an increase of "redness" with unusual fulness and a tortuous course of the retinal veins over and near the hyperæmic portion.

INFLAMMATION OF THE CHOROID. CHOROIDITIS.

The general remarks which were made upon iritis apply equally to choroiditis.

As regards different forms of choroiditis we distinguish—

(1.) Simple or plastic. See Plate VI. Fig. 12, and Plate VII. Fig. 13.
(2.) Syphilitic.
(3.) Traumatic and Sympathetic; and
(4.) Serous Choroiditis.

Certain symptoms are common to all forms of choroiditis; these are: loss of transparency of the choroid and atrophic changes.

Others are peculiar to different forms; from these special names are derived. Lymph nodules are observed in the syphilitic; large grey or yellow and opaque patches in the plastic,—a "turbid" red colour of the choroid, and increased tension and dilatation of the pupil, in the serous forms of choroiditis.

Choroiditis can, to insure accuracy of diagnosis, only be recognized with the ophthalmoscope. External and objective symptoms may be absent altogether. Pain, intolerance of light, impairment of vision, fulness of the veins emerging from the sclerotic in the ciliary region, sclerotic redness, a sluggish pupil, &c., are symptoms frequently observed, but not characteristic of any of the forms of choroiditis.

In portions of choroid near the ora serrata choroiditis may run its course unobserved.

Ophthalmoscopic observations show that, as regards duration, choroiditis differs little from similar forms of iritis, unless implication of other tunics be a source of prolonged disturbances.

The state of vision varies according to the seat, extent, and severity of the inflammation, and according to its effect upon the retina or optic disc.

Small inflamed spots, implicating the retina at the yellow spot, give rise to complaints of disturbed vision; whilst large portions of choroid, near peripheral parts of the retina, though the retina be perhaps more extensively affected, may run through all stages of inflammation, and neither disturb vision nor give rise to other complaints.

Solitary portions of choroid, when impairing the functions of corresponding parts of the retina, give rise to loss or impairment of the functions of these parts. These may be paralysed, completely destroyed, or merely reduced to perception of light.

A gradual transition from less sensitive to normal parts of retina is the rule in circumscribed choroiditis.

The prognosis, as regards recovery of inflamed parts of the choroid, is more favourable if no atrophic patches are perceptible.

As regards vision it is less favourable, if the inflammation is at or near the region of the yellow spot, and if the retina over the inflamed part is quite paralysed.

Among the changes which are peculiar to choroiditis, and which are observed with the ophthalmoscope, we must distinguish those which are produced by the "exudation," those which are the result of hyperæmia or of atrophy of the choroid, and those which are situated in the retina or optic disc or vitreous chamber.

The "exudation," seen with the ophthalmoscope, appears generally of a grey or yellowish, rarely of a brown and opaque colour; it assumes the shape of roundish spots, or of large patches surrounded by vascular ("red") choroid. Only one large portion of choroid, or one or numerous small isolated spots, and in severe cases the entire choroid, may be occupied by "infiltration."

Round the choroidal aperture, and in the region of the yellow spot, the infiltration frequently appears in the shape of roundish spots and patches. These gradually disappear, and the changes of atrophy, &c., are observed in and round the portion of choroid which they occupied.

Minute examination has shown that in the portion of choroid occupied by the infiltration, the blood-vessels are obliterated partly by the exudation, and partly by changes in the contents of the vessels themselves. The hexagonal cells as a rule are either pushed aside by the exudation or they become discoloured; whereas the groups of stellate pigment cells appear smaller, and often disappear during further changes of the exudation. The choroid adjoining the exudation sometimes appears œdematous and hyperæmic: in many cases, when viewed with the ophthalmoscope, no satisfactory view can be obtained on account of its being masked by alterations in the retina, vitreous, &c. The transparency of the retina, over and near the focus of inflammation, is impaired in most cases. The greyish, hazy retina merges gradually into transparent portions. The vessels may be lost sight of in the hazy portions of retina, or may appear varicose and enlarged (see Plate VII. Fig. 13). Blood spots occasionally appear from rupture of small vessels.

Choroiditis at, or near, the Optic Disc.

The inflamed portion of choroid is readily recognized by the outlines of the optic disc appearing ill-defined. The optic disc may become as red as the choroid; and often can hardly be recognized but for the enlarged retinal veins meeting in it. The disc in other cases appears anæmic in the

middle, and very congested next the choroid ; or part or the whole of the disc may be occupied by "exudation." The appearance of the disc varies according to the stage of the inflammation. Destruction of the optic nerve fibres by choroiditis at the choroidal aperture (in one or both eyes) is not an uncommon occurrence.

Opacities in the vitreous chamber, near the seat of choroiditis, are usually present; and are often the only symptoms noticed by the patient, who, if these opacities are close to a sensitive portion of retina, complains of black spots, clouds, &c., floating before the eyes.

Iritis, and hyperæmia of the iris, are frequent complications. (See Syphilitic Choroiditis and Inflammation of the Optic Disc.)

Treatment.

The treatment of the different forms is the same as that of corresponding forms of iritis.

If mercury is given, with a view of producing salivation within a few days, it is best to employ frictions with mercurial ointment (from one to three drachms to be rubbed into the armpits twice daily).

No treatment seems of use when atrophic spots have become visible in the choroid.

ATROPHY OF THE CHOROID.

Atrophy may be the result—

(1.) Of inflammation of the choroid (see Plate VII. Figs. 14, 17); (2.) Of distension of the choroid (see Plate VIII. Figs. 21, 22); (3.) Of senile changes; (4.) Of degeneration (see Plate VIII. Fig. 18; Plate VIII. Figs. 19, 20); or (5.) Of combinations of the above (see Plate VIII. Figs. 23, 24).

The atrophic portions of choroid, viewed with the ophthalmoscope, are conspicuous by their contrast with the parts adjoining them.

Transparent portions represent the highest degree of atrophy. In these the pigment and blood have disappeared, and only a thin transparent membrane is left. These portions, in the living, appear as brilliant white patches, spots, &c., the white colour being caused by the sclerotic which subtends the transparent and atrophic choroid, and from which the light is reflected. These transparent portions, as a rule, are surrounded by pigment spots. These and the transparent spots are found side by side.

Atrophic portions of choroid often skirt the optic disc in the form of crescents in the myopic eye; they are observed as small, well-defined, brilliant white and brown, or black spots in other portions of choroid after various forms of choroiditis, &c.

Pigment spots are the results of changes in the hexagonal cells, or in the stellate pigment cells, and may assist in localizing morbid changes of the retina or choroid.

Every inflammation is accompanied by pigment changes. The pigment granules of the hexagonal cells, over and near the seat of inflammation, become too transparent or too much tinted. They decrease in number, or are destroyed, or they become displaced and accumulated round the foci of inflammation. Hence the groups of circles or spots of deep brown and black pigment which skirt transparent atrophic parts of choroid, or which are scattered over more or less anæmic portions.

Pigment spots caused by groups of stellate pigment cells cannot be mistaken for those due to alteration of the hexagonal cells and of their granules; since the shape of the former, in different parts of the choroid, is sufficiently characteristic. Alterations in colour of groups of stellate pigment cells (from a light to a dark brown and vice versâ), or a diminution of tint (from light brown to pale yellow, or to complete transparency), are observed in prolonged anæmia of the choroid, and especially in atrophy and in staphyloma. In health we find that the darker the iris the deeper is the tint of the choroid.

The choroid which undergoes atrophy, may appear light red before it becomes transparent. If there is staphyloma at the same time, we find at its margin the large choroidal vessels unusually broad and farther apart from each other, and also the vessels of the retina deviating from their normal course.

The choroid, retina, and sclerotic are adherent to each other at the transparent atrophic spots, and frequently also at the pigment spots.

DISPLACEMENT OF THE CHOROID.

Displacement of the choroid has been observed in the course of cancer and other tumours, and also after effusion of transparent fluid or of blood between choroid and sclerotic.

The displacement has been observed in young persons suffering from irregularities incident to menstruation, frequently in glaucomatous eyes, and but rarely after injury.

The equatorial region of the eye is the usual seat of the displacement; though, in several cases, it has occurred at the yellow spot.

Viewed with the ophthalmoscope, the displaced portion appears as a dark brown sharply-defined roundish patch, with semitransparent retina over it, and surrounded by the natural colour of choroid and retina. In those cases in which large portions had become detached, no light reached the sclerotic, and all appeared dark behind the clear crystalline lens. (See

Plate X. Fig. 32.) The eye could not be lighted up with the ophthalmoscope. In some cases this condition was masked by displacement of the retina. Sudden impairment of vision, to correspond to the displaced portion of choroid, was observed in some cases.

Decrease of tension with gradual shrinking of the eye occurred in some cases; whereas in others the blood became absorbed, and this was followed by circumscribed atrophy of the choroid with loss of vision from atrophy of the retina.

Bone upon the Choroid.

True bone has been observed in the choroid of the living eye with the ophthalmoscope. Specimens may be seen in numerous preparations in the Museum of Guy's Hospital.

Few of the eyes in which bone has been found have been of normal shape; they generally have been more or less shrunken. In some the bone has reached a thickness equal to that of the sclerotic. It has been, as a rule, most considerable round the optic disc, with an opening for the passage of the optic nerve.

The bone substance in most cases has had the shape of a cup, the outer surface of which has joined the choroid, whilst the inner has been separated from the displaced retina, either by fluid or connective or fibrous tissue. The cup has decreased in thickness from the optic disc towards the ora serrata. In some instances it has extended as far as the insertion of the iris, its outer surface adapting itself to that of the ciliary processes. In others a ring of bone has been found upon the choroid along the ora serrata, and again round the optic disc, whilst the inner surface of the choroid, between these points, has been strewed with granules of chalk, and with blades of cartilaginous substance.

The exudation, accompanying plastic or purulent choroiditis, gives rise to such ossifications. Suppuration round the bone cup, and abscess within it, are not unfrequent causes of "inflammation" of a "shrunken eyeball."

Tubercles in the Choroid.

In a person who died of "miliary tuberculosis" six greyish-white and opaque nodules were found in the otherwise healthy choroid. They were situated beneath the hexagonal cells, some round the optic disc, others near the ora serrata. Examined minutely, they consisted of cells of varying size (with one or several nuclei), of free nuclei, and of some amorphous matter (in the centres of the nodules).

The patient never complained of impairment of vision, and never had "inflamed eyes."

Colloid Changes.

Colloid changes in the choroid are peculiar alterations of its various component structures, and more particularly of its elastic lamina. This lamina becomes brittle; and projecting from, and forming part of it, are roundish wart-like elevations, which vary in size. The larger ones are readily seen with the naked eye when looking slantingly at the inner surface of the choroid; the latter, instead of being smooth, appear strewed with minute grains. These are large colloid globules.

Examined with the ophthalmoscope in the living eye, they appear as ill-defined brownish beaded lines and spots. The choroid beneath and around them presents a peculiar dull-red "turbid" colour. Little is known as regards the kind of impairment of vision produced by colloid globules. They occur at all ages, and have been found in shrunken eyes of young, and in normal-shaped eyes of old persons.

In recently excised eyes the blood may be seen passing through the capillary vessels of the choroid beneath the colloid globules. The coats of the capillaries and of the larger vessels (veins) are often found thickened by colloid substance, so as to diminish their permeability and sometimes to obliterate portions of a vessel.

The colloid globules, examined microscopically, are found solitary or in clusters; or several coalesce, and form irregular nodular projections. They vary in size.

Each colloid globule appears roundish, smooth, and well-defined, and, when fresh, almost transparent; it reflects the light strongly. The small ones, like the elastic lamina, appear structureless. Concentric lines become visible on the cut surface of large ones. The globules frequently calcify and then appear greyish, less translucent, and finely granular on the surface. In this stage, on addition of acids, numerous air bubbles are developed. When fresh the globules resemble chemically the elastic lamina; they are very hard, and resist acids and alkalies for a long time. They become somewhat paler when treated with weak acids and alkalies, and assume a brown colour on addition of Iodine or of Sulphuric Acid.

They give rise to striking changes in the hexagonal cells ("the choroidal epithelium"). These rarely form an uninterrupted surface over the colloid globules. Their granules appear, some unusually saturated with a brown colour, others pale or fewer in number. Many are missing. They generally are displaced, and lie loosely over or round the bases of the colloid globules. The hexagonal cells lose their outlines altogether, or become round, or are partly destroyed.

GLAUCOMA.

Arthritic Ophthalmia. Choroiditis Serosa. (See Plate IX. Figs. 26, 27, 28, 29.)

Formerly the term glaucoma was applied to the last stage of the disease only, viz. that in which the pupil had become fixed, irregular, and dilated, its area greenish, the ciliary vessels enlarged, the eyeball of stony hardness, and vision lost, &c. With our improved means of diagnosis we can discover the signs of glaucoma in persons with apparently perfect sight.

The term glaucoma is at present applied to a series of morbid changes of the eyeball; the most prominent of which and apparently the one which causes nearly all the others, is an increase in the tension of the eyeball.

This increase of tension, or, in other words, the abnormal resistance of the tunics of the eyeball to the touch, is attributed to an increased amount of, and to changes in the contents of the vitreous chamber, which give rise to disturbances in the circulation, nutrition, and functions of the textures of the eyeball. No satisfactory explanation can as yet be given of the primary cause of the increased tension; whereas most of the subsequent changes in the textures of the eyeball are readily explained by reference to it. These changes, in the majority of cases, are accelerated by attacks of inflammation, which either appear suddenly with remissions, or as chronic inflammation, with slight exacerbations. These attacks of inflammation themselves are symptoms of disturbed tension.

Their occurrence, succession, and rapidity seem to depend, in a great measure, upon the power which the eye possesses of adapting its nutrition and circulation to the disturbances occasioned by the increased tension.

Glaucoma, when appearing without attacks of inflammation, is termed *simple glaucoma.* The increase of tension, and the changes resulting from it appear gradually, and proceed without any external inflammation. If attacks of inflammation accompany the glaucomatous state of the eye it is termed *chronic or acute glaucoma.*

Chronic glaucoma, or, rather, glaucoma with slight attacks of inflammation, is the most frequent form. The attacks of inflammation occur at first at long intervals, are slight, and not well marked.

In acute glaucoma, or, rather, in glaucoma with acute inflammation, the latter is severe in character and sudden in its onset.

Simple or chronic glaucoma may appear in one eye, and acute glaucoma in the other. An acute attack of inflammation may occur in an eye with chronic glaucoma; and *vice versâ,* e. g. an eye suffering from acute glaucoma may, after the attack has subsided, assume the aspect of chronic

glaucoma. The gradual and often hardly perceptible progress of the glaucomatous changes, with only slight attacks of inflammation, and with little or no pain, finally produce the same well-marked glaucomatous aspect of the eye as an acute attack of inflammation does in a short time.

To be able to recognize glaucoma in its different forms and stages, we must be familiar with the normal tension of the eyeball (see Tension of the Eyeball), and with the glaucomatous symptoms peculiar to the different textures of the eye.

Glaucomatous symptoms, i. e. such as are occasioned by an increase of tension in the eyeball, have been mentioned when speaking of other morbid changes of the eyeball (as cataract, corneitis, iritis, and myopia). Here again we find that a thorough acquaintance with the alterations of the tension of the eyeball as well as the recognition of symptoms and changes depending upon it, are of the greatest service in the treatment of these morbid changes.

The progress of glaucoma in the majority of cases is accompanied at one period by attacks of inflammation. These attacks attract the patient's attention particularly on account of their generally being accompanied by impairment of vision, and pain.

They vary as regards severity, frequency, and rapidity of appearance.

If severe and sudden, they are termed acute. An attack may pass off, and some time intervene between it and a fresh one. The interval between the attacks becomes, as a rule, shorter in the later stages of glaucoma. Often a severe attack follows several slight and rapidly succeeding ones.

An acute attack, however, often appears without other symptoms having attracted the patient's attention. Cases have occurred in which vision has been lost suddenly a few days previous to the appearance of the acute inflammation.

Acute inflammation has been observed in glaucomatous eyes which had been blind for years, and in eyes the sight of which had been lost by cerebral amaurosis.

A patient suffering from an attack of glaucoma with acute inflammation generally states that he was seized with sudden severe pain in the eye (frequently while in bed, or after having passed some sleepless nights, or after having been subject to excitement). He describes the pain as extending over the corresponding side of the head, and more especially over the forehead and temple, and says that on closing the other eye he has found that with the painful eye he cannot see, or, at best, but very imperfectly.

Should the patient be seen the same day, or one or two days after the attack, we generally find the eyelids slightly reddened and swollen along their margins; the conjunctiva somewhat chemotic, with its blood-vessels and those of the sclerotic numerous and enlarged; profuse flow of tears, and often much intolerance of light; and the aqueous humour turbid.

The pupil is more or less dilated, often immovable and irregular; vision much impaired, sometimes reduced to bare perception of light; the pain is severe in the eyeball and over the forehead and temple; the tension of the eyeball is increased.

The changes observed with the ophthalmoscope are stated below, together with other glaucomatous changes of the textures of the eye.

The acute inflammation after a few days or weeks passes off spontaneously, although gradually unless it be treated properly.

The functions and structures of the eye remain more or less altered. Similar acute attacks may appear repeatedly; but more frequently the eye assumes the characters of "chronic glaucoma."

The symptom which most distresses the patient, when suffering from glaucoma with slight attacks of inflammation ("chronic glaucoma"), is the temporary "dimness" of vision. On inquiry we generally find that these "attacks of dimness" coincide with those of slight inflammation. The symptoms of the latter are—more or less pain in and round the eyeball, with increase of the already abnormal tension; undue vascularity of the conjunctiva and of the sclerotic along the margin of the cornea; slight turbidity of the aqueous humour; and sluggishness of the movements of the iris.

The course of simple glaucoma is still less striking than that of chronic glaucoma. Attacks of inflammation, acute or chronic, may appear during any part of the course, sometimes only after vision is destroyed.

To recognize glaucoma in its simple form, we must be familiar with the use of the ophthalmoscope, and with the mode of ascertaining the tension of the eye.

Simple glaucoma is often mistaken for cerebral amaurosis.

Vision becomes impaired gradually, the power of accommodation lost, and the pupil sluggish, and more or less dilated. The increase of tension, the mode of impairment of vision, the alterations of the optic disc and of the retina, when seen with the ophthalmoscope, are in themselves sufficiently characteristic to prevent our mistaking this, or any other form of glaucoma.

The glaucomatous symptoms, as exhibited by the various structures of the eye, require a more detailed description.

The increase of tension of the Eyeball is, as far as is known, the earliest perceptible symptom of glaucoma; it may precede most of the others for some years.

The tension, though remaining above par, varies in degree at different periods; and likewise varies in its effects upon the different structures. A retina, for instance, may have become completely paralysed by pressure, while the sensibility of the cornea and the shape of the pupil, &c., are but little altered.

The tension increases suddenly during an acute attack of inflammation.

The hardness of the glaucomatous eyeball reaches its height soon after vision is lost, and continues for a long period.

As one of the later and rarer changes in the blind glaucomatous eye must be mentioned a fluid condition of the vitreous substance with dislocation of the chalky crystalline lens and a decrease of tension to T —2. The tension of the glaucomatous eye, after removal from the orbit, sinks below par in some instances; in others it remains unaltered.

In many cases the tension is reduced to the normal degree soon after iridectomy, and at a later period it may sink below par.

In another series of cases the tension remains a little above par after iridectomy; whereas in glaucoma, complicated with attacks of profuse hæmorrhage into the vitreous chamber, it often is not altered at all, or only at a late period.

The same has been observed when, in young persons suffering from glaucoma, the iris has been much pushed forwards previous to the operation.

If a well-performed iridectomy does not reduce the tension, a second operation should be tried: this sometimes succeeds in controlling the tension.

The Eyeball becomes more globular in shape.—Alterations in curvature of the cornea, staphylomatous portions behind and at the side of the insertion of the recti muscles, and in the equatorial region and beneath the insertion of the oblique muscles, often occur in later stages of the disease.

Staphylomata decrease much, and sometimes disappear after successful iridectomy.

The conjunctiva in simple and in chronic glaucoma is remarkable for its rotten condition. Together with the subconjunctival tissue it becomes atrophic, and readily tears, when seized, so as often to be quite useless for fixing, or rotating the eye during operation.

It becomes chemotic and vascular in "acute glaucoma."

The sclerotic, in acute glaucoma, appears slightly reddened.

The ciliary vessels, which emerge from the interior of the eye through the sclerotic, especially in front of the insertion of the recti muscles, are large, tortuous, and numerous in most cases of chronic glaucoma, although they often become smaller, or disappear entirely in the later stages, or after successful treatment.

The cornea gradually becomes anæsthetic. The anæsthesia at first may be confined to certain parts, but it disappears if the tension is relieved in time.

In the later stages the shape of the cornea often suffers, some parts (the more paralysed ones) becoming staphylomatous. Softening of the cornea, and chiefly of its central portion, advancing from the surface inwards, has been observed.

The cornea may become more or less opaque. Sometimes a crescentic ulcer, or diffused purulent infiltration occurs, which may be followed by perforation, intra ocular hæmorrhage, and shrinking of the eye.

The latter result may also follow when the suppuration spreads from the cornea into the eye.

The aqueous humour and its chambers.—The anterior chamber appears smaller through the iris and crystalline lens approaching the cornea—in some instances to such a degree as to touch the cornea in certain places. The quantity of the aqueous humour is diminished. These changes in the aqueous chambers may be missing in any form of glaucoma; they have also been observed in young glaucomatous persons.

The diminution in the size of the aqueous chamber occurs slowly in chronic, and often quickly in acute glaucoma.

It is a favourable symptom if the size of the chamber increases after iridectomy.

Attacks of inflammation cause the aqueous humour to appear turbid; this turbidity may disappear after a few minutes; or it may appear and disappear several times in the course of the day.

Spontaneous hæmorrhage from the vessels of the iris in the aqueous humour is a frequent occurrence.

The iris gradually loses its mobility, partly through pressure upon the ciliary nerves, partly through atrophic changes.

The iris hardly ever returns to the normal condition, though an iridectomy may otherwise have been successful. It has been observed that, if only part of the cornea has lost its sensibility, the corresponding portion of iris has alone been paralysed.

In acute glaucoma the mobility of the iris may become arrested at once, whereas in simple and chronic glaucoma this occurs slowly.

The colour of the iris appears altered, according to the stage of the glaucoma—the dilatation of the blood-vessels—the complication with iritis,—and the state of the aqueous humour.

Enlarged blood-vessels are often seen with the naked eye in the iris, especially in simple glaucoma. The iris at last becomes atrophic, and assumes a slate colour; and its rotten condition renders removal by iridectomy very difficult.

The pupil is, in many cases, at first unusually contracted. Its movements gradually become sluggish, and generally somewhat irregular. In the later stages of glaucoma, unless prevented by adhesions, it becomes widely dilated and motionless. Cases of simple glaucoma often occur in which the pupil, though immovable, retains a medium size.

In the choroid we observe—(1.) Hæmorrhage (? from impeded return

of blood). (2.) Anæmic spots. (3.) Atrophy extending (as in the retina) from the ora serrata backwards. (4.) Staphylomatous changes in the atrophic parts.

The hæmorrhage frequently occurs in the equatorial region and in the region of the yellow spot. The blood is accumulated in the outer layers of the choroid, and between the latter and the sclerotic.

These blood spots, when viewed with the ophthalmoscope, appear as black or brown, roundish, ill-defined patches, surrounded by the natural red reflection from the choroid; not unfrequently they are situated close to atrophic portions.

Only after operations (iridectomy, extraction of cataract, &c.) has the hæmorrhage been so great as to separate the choroid nearly completely from the sclerotic.

The anæmic spots, as seen with the ophthalmoscope, appear roundish, white, well-defined, and in groups. They are mostly observed in the region of the yellow spot, and near the optic disc.

The staphylomatous atrophic portions of choroid (and other tunics) are usually found in front of the equator, between it and the ora serrata, and by preference behind the insertions of the muscles. Viewed with the ophthalmoscope, they have a pale red colour, which is the more marked the greater the atrophy of the choroid. This form of atrophy differs from other forms, on account of the frequent absence of pigment patches round the atrophic portions.

Microscopic examination of the choroid in chronic glaucoma shows the large veins and the capillaries gorged with blood, and much dilated.

The stellate pigment appears normal round the optic disc, as well as in most other parts of the posterior half of the choroid. From the equatorial region to the ora serrata it is thin and atrophic in some, and completely missing in other places. The hexagonal cells round the optic disc appear normal, or nearly so as regards size, shape, and pigmentation. They are more altered nearer the ora serrata. Upon the atrophic parts of the choroid they are missing, near these parts they appear rugged in some, and round and unusually large in other places. Some are filled with pigment granules, whilst others contain but few, or are entirely empty; many of the granules themselves appear abnormally large. Colloid globes or globules, disarranging the regularity of the cells, are found in a few cases only.

The changes in the blood-vessels and in the pigmentation are in all cases most conspicuous from the equatorial region to the ora serrata. The texture of the choroid is rotten.

The crystalline lens in the later stages of glaucoma assumes, as a rule, a greenish tint, which, however, is not characteristic of glaucoma.

Light, reflected from the hyaloid fossa, returns through the crystalline lens, and mixes with the slightly bluish-grey light which is reflected from the anterior surface of the capsule, and from the portions of the lens adjoining it. The greenish tint disappears from many eyes successfully operated upon; it becomes less marked after removal of the aqueous humour. The lens when removed from a glaucomatous eye appears of a pale orange colour (from imbibition of hæmatin).

The position and the consistence of the crystalline lens become altered; its capsule, like the other textures, becomes rotten and readily ruptured spontaneously, or during iridectomy. The cataract which follows, or which may appear spontaneously, has a peculiar uniform grey or greenish-grey and opaque colour, which sometimes is preceded by large silvery striæ. The cataract at first is very large (swollen); gradually, chalky patches appear, with loosening of the attachments of the cataract, and sometimes with dislocation into the vitreous chamber.

The vitreous substance in cases of acute glaucoma, when examined soon after the attack, is found transparent and of normal consistence, with clots of blood suspended in it.

In chronic glaucoma it possesses unusual firmness; it is transparent with a more or less yellowish tint. Clots of blood are comparatively rare in the vitreous chamber; if present they are more numerous along the ora serrata and near the hyaloid fossa.

In a staphylomatous eye, and in one in which the choroid had been separated from the sclerotic by spontaneous hæmorrhage, the vitreous was more viscid in consistence; it was nearly fluid where it touched the displaced or staphylomatous portions of the tunics.

Part of the vitreous may be missing (having become absorbed?), and the entire hyaloid membrane may be separated by yellowish fluid from the membrana limitans of the retina.

Impaired transparency of the retina and choroid render recognition of the state of the vitreous difficult.

Loss of transparency of the vitreous, if no clots of blood are visible in it, is, as a rule, only apparent and not real; it is produced by the little light which returns from the sclerotic through the turbid retina and choroid.

In the retina we observe anomalies of the blood-vessels, blood spots, and impaired transparency.

The blood-vessels.—Differences in diameter, together with alterations in the course of the vessels in the optic disc, compared with those in the retina, are among the characteristic signs of glaucoma. The retinal veins are often already abnormally thin (compressed) on the white ring which sur-

rounds the optic disc; while in the retina they are large, unequally dilated, often tortuous, but, like the arteries, as a rule, less numerous than those in the healthy eye of the same age. They are also less numerous in the eye in which the glaucomatous changes are most advanced.

The arteries always appear unusually thin.

Blood-spots (so-called capillary hæmorrhage) are met with in every glaucomatous retina. They occur more frequently along the ora serrata, and more rarely round the optic disc and yellow spot. Only few may be found in simple or chronic glaucoma, whereas a great number may appear in acute glaucoma, or after sudden diminution of tension (as after iridectomy).

The blood-spots are mostly situated at the junction of veins; and are well-defined, and roundish—a shape which might almost be considered characteristic. They most frequently appear in the thickness of the retina, but may occasionally be seen in the vitreous chamber, or between the retina and choroid (where they appear large and flat). They may occur simultaneously in all these places. They gradually become darker, smaller, and finally are lost sight of. Those between the retina and choroid disappear sooner (giving rise to irregularities of the "choroidal epithelium") than those in the vitreous, or those between the retina and hyaloid membrane.

Blood-spots are an unfavourable complication, and often impair or even destroy the benefit derived from iridectomy; especially if they are large and near the optic disc, or at the yellow spot.

They have occurred months after the iridectomy, and without the recurrence of other glaucomatous symptoms. Patients suffering from renal disease are especially liable to them.

Those familiar with the brilliant red colour of the choroid in a fair and healthy eye must have been struck with the turbid or hazy appearance of the choroid in a similarly coloured eye when glaucomatous. From dissection it appears that the destruction of the retinal elements, together with the presence of numerous pigment molecules and débris of blood, is the cause of this abnormal absorption of light.

Clots of blood and opacities in the vitreous chamber, as well as hæmorrhage between the choroid and retina, or between the choroid and sclerotic, may also prevent our seeing the retina, optic disc, &c.

Dissections of numerous Glaucomatous Retinæ removed from the living body.

The retina appeared in all cases transparent to the naked eye. In two cases of chronic glaucoma the tint peculiar to the region of the yellow spot was no longer perceptible. In all cases of chronic glaucoma small round blood-spots were observed, and most frequently near the optic disc.

Numerous blood-spots were found in acute glaucoma, especially along the ora serrata (and some between the choroid and retina, beneath the most depending equatorial part of the retina, with streaks of blood hanging into the vitreous chamber).

The texture of the retina was found to be very rotten in chronic glaucoma, particularly so at and near the ora serrata; in some places it could only be removed in small shreds.

The rods and bulbs (in chronic glaucoma) could be recognized round the optic disc and in the region of the yellow spot; but even here they appeared enlarged, less well-defined, and in some places semitransparent. Their change of shape, indistinctness of outline, and loss of transparency (when detached from the choroid) increased towards the ora serrata. In this locality and close to it the outer surface of the retina had an uneven, amorphous, greyish, semitransparent appearance.

The fibres of the retinal framework (the radiating fibres) could be recognized round the optic disc and in the region of the yellow spot; they appeared thin and ill-defined. In other places they were very ill-defined or missing, and the granules appeared indiscriminately heaped together.

Large oval or round cells, or transparent spaces, resembling cells of various sizes, occurred, especially near the ora serrata, in large numbers in every retina in chronic glaucoma. Many seemed to occupy the entire thickness of what remained of the retina. These cells on section proved to be lacunæ among the radiating fibres.

The fibres of the framework were destroyed wherever the optic nerve fibres were missing (only in one eye could the inner membrana limitans with the fibres opening into it be recognized).

The thickness of the granular layers appeared below par even in the region of the yellow spot. In many places near the ora serrata no granules, or only a few, could be recognized. These were unusually large, and on addition of chromic acid did not exhibit any nuclei.

The ganglion-cells, and the so-called "grey nervous matter" were changed into a finely-granular semitransparent mass, sprinkled with grey and brownish opaque patches, and (in many places) with fresh blood-spots.

The optic nerve fibres could only in a few eyes be recognized as a thin layer near the optic disc. Minute black pigment granules, having an arrangement similar to that of the nerve fibres upon the retina, were observed in other places.

The increase in the number of the capillaries of the retina was remarkable even along the ora serrata, where the other retinal elements appeared reduced to a semitransparent amorphous substance. Everywhere did the capillaries appear enlarged and varicose with portions of their walls bulging out so as to form pouches (aneurismata) of varying size. A few of these

pouches were filled with a black, brownish, or yellowish amorphous substance. The veins were varicose in many places. A loss of substance in their inner coat with a bulging of the thus weakened wall were frequently observed.

Several times perforation of the lower or lateral wall of a vein could be demonstrated together with an accumulation of blood in the adjoining retina.

The large veins ceased abruptly at the choroidal margin of the cupped optic disc; in the cup they appeared collapsed in some, and adherent to the walls of the cup in other eyes.

The walls of some of the arteries appeared thickened.

The optic disc, and the blood-vessels in it, present in all cases of glaucoma one or several of the following changes—

(1.) Changes in the calibre, course, and pulsation of the blood-vessels in the area of the optic disc as compared with those in the retina.

Their calibre (see Plate IX. Figs. 27, 29). When viewed with the ophthalmoscope we observe that those portions of the retinal veins which are situated in the retina, as a rule appear wider and somewhat tortuous; whereas at the margin of the optic disc the same veins at once become narrow; some can barely be traced across the disc, others are lost sight of altogether.

Their course is altered on account of changes of the surface and substance of the optic disc.

The pulsation.—Glaucomatous eyes are remarkable for the facility with which pulsation of the retinal arteries in the optic disc is produced by the slightest pressure upon the eyeball (as may be seen with the ophthalmoscope).

The pulsation, which is nearly synchronous with that of the radial artery, consists in a brisk emptying and filling of those portions of the retinal arteries which extend from the point where they appear in the optic disc to where they reach its margin. The pulsation is met with in the early stage, and at different periods probably in all cases of glaucoma; it comes under observation more particularly in glaucoma with slight attacks of inflammation.

Changes of the surface of the optic disc.—The surface of the optic disc, instead of being slightly above the level of the retina, becomes depressed (cupped) through pressure upon, and gradual destruction of the optic nerve fibres, connective tissue, &c. We distinguish between the margin, the sides, and the bottom of the cup.

The margin of the cup is prominent, sharp, and generally formed by the sclerotic alone (i. e. by the inner edge of the sclerotic aperture which projects most into the area of the cup).

A white ring round the optic disc, or a white crescent skirting its outer margin, is in many cases observed in the early stages of glaucoma.

The sides and the bottom of the cup are formed by the sclerotic, by a varying quantity of optic nerve fibres and their débris; and also by the trunks of the blood-vessels. The cup itself is filled with fluid and vitreous substance.

Some idea of the bulk of optic nerve fibres, which have escaped destruction, may be formed by observing the line of demarcation between these and the vitreous in the cup.

The cup is at first shallow and confined to part of the optic disc. It is generally observed first in the lower, and in some cases in the outer portion of the optic disc; it becomes gradually steeper and deeper, and often extends beyond the outer sclerotic aperture.

The (sclerotic) margin of the cup, if it projects considerably, gives rise to a bluish-grey crescentic shadow when we throw light with the ophthalmoscope into the cup. The shadow shifts about according to the direction from which the light comes.

The retinal vessels, on their way to and from the retina, have to pass through the cup, and necessarily present changes in their course, calibre, &c., which are characteristic of the cupped condition of the optic disc. To the less experienced ophthalmoscopist they afford the only certain ophthalmoscopic signs of the existence of the cup.

The greater number of vessels are, as a rule, pressed against the sides and margin of the inner (nasal) portion of the cup. The veins coming from the retina, on arriving at the margin of the cup, bend round it and run along the sides. For a moment they are lost sight of if the margin is very prominent, and a portion of the veins hidden from view behind the margin.

The portions of the veins in the cup appear displaced, and no longer seem to be prolongations of their corresponding portions in the retina. This deceptive appearance is increased by the veins in the cup being much smaller than those in the retina. In no other form of cup but the one caused by pressure is this apparent change in the calibre of the veins observed.

The cup is met with in the later stages of all forms of glaucoma; it generally varies in degree in the two eyes of the same person. In eyes with "normal vision" previous to an acute attack of inflammation we often do not at first find the cup, but a pink or red optic disc.

The cup increases in depth most rapidly if acute inflammation appears in "chronic" glaucomatous eyes. Hæmorrhage into the cup is not uncommon, and causes it to appear red. Its contents, if mixed with blood, may be mistaken for the natural colour of the optic disc unless attention be paid to the appearance of the retinal vessels in the disc.

The optic disc and cup appear in most cases anæmic (of a grey or waxy-white colour).

Iridectomy produces a marked change (see Plate IX. Fig. 26). The retinal vessels in the cup become more numerous and larger. Few days after the operation their course already appears altered; they seem straighter, and can be uninterruptedly traced from the retina into the apparently more shallow cup. The optic disc remains more or less anæmic. The whitish colour, unless accompanied by diminution of vision, need not alarm us.

The shadow, thrown by the projecting margin of the cup, becomes less marked, and the colour caused by staining of the cup with blood disappears rapidly.

In glaucomatous eyes removed from the living body we find the transparent portion of the optic disc (i. e. the optic nerve fibres as well as the connective tissue) missing. The cup, thus formed, is filled with yellowish fluid in some, and with blood mixed with vitreous substance in other cases.

As the result of ophthalmoscopic examination of numerous eyes, the fellow eyes of which suffered from glaucoma, there was found—

(1.) Pulsation in many cases (spontaneous or produced by the slightest pressure upon the eye).

(2.) In many cases, whatever the form of glaucoma in the fellow eye, a somewhat anæmic optic disc with a narrow whitish ill-defined ring surrounding it. In a few cases a highly hyperæmic optic disc with the same white rim round it (see Plate IX. Fig. 28).

(3.) A marked decrease in the size and number of the arteries.

Mode of Impairment of Vision.

In simple glaucoma the impairment is so gradual that the sight of one eye may be lost without the patient being aware of it. Some patients state that vision has been lost gradually, both for distant and near objects, and this has been accompanied at times by rainbow colours round luminous objects.

Symptoms of glaucoma may exist for twelve or sixteen years before vision becomes sensibly impaired.

In "chronic glaucoma" we usually hear the patient complain of "attacks of dimness,"—of a "mist" round the flame of a candle,—and in most cases, on inquiry, of "rainbow colours." Many observing patients state that, when looking straight forward, they no longer perceive objects held sideways.

The "attacks of dimness" are observed by most patients, and are supposed to coincide with temporary increased pressure upon the optic nerve (optic disc) and retina.

The retina and optic nerve may thus be paralysed without the optic disc appearing cupped.

Fatigue, excitement, and stooping are the usual causes of these attacks, which may appear at different times of the day, but generally do so towards evening.

Vision becomes "dim" not only when reading, but also when looking at distant objects; a mist appears to intervene between the eye and the object looked at.

"Normal sight" may permanently be destroyed within a few minutes by acute glaucoma. Though reduced to perception of light, it may return to what appears to the patient a normal condition. In most cases, however, vision remains impaired.

The perception of "colours," of a "rainbow" round luminous objects (termed "*irisation,*" whether all the colours of the prism are present or not), is one of the most constant symptoms of glaucoma.

The colours generally assume the shape of a rainbow in which the margin most distant from the flame appears red, and the one nearest the flame green or bluish-green.

Irisation, though generally not in the form of a rainbow, is observed by persons suffering from granular ophthalmia, and by many healthy eyes, if the pupil is much dilated.

Irisation has been known to exist for ten or fifteen years previous to vision becoming impaired. In some cases of glaucoma it does not occur at all, in others only at certain stages, and disappears if the pupil is contracted beyond a certain size.

"Fiery stars," "flashes," intolerance of light, &c., are only occasionally observed.

In presbyopic persons, who use spectacles, we may suspect the presence of glaucoma if their spectacles are repeatedly changed in the course of a few months.

The statements of the patient, as regards vision, should be followed by an examination of the functions of the retina, and when ascertaining these we should pay particular attention to the condition of the peripheral portions of the retina. For a patient may be able to read small type (held opposite the region of the yellow spot), and yet may have lost the use of the surrounding retina.

The peripheral portions of the retina are found impaired in all forms of glaucoma, and are often destroyed before vision for reading is much affected.

In simple glaucoma increased tension may exist for a long time before any diminution in the function of the peripheral parts of the retina is observed. The impairment at the commencement is only discovered when the examination is made in dull light. The peripheral parts of the retina,

which lie to the outer side of the yellow spot, are generally first impaired.

Cases often occur in which the movements of the examiner's hand (the patient's eye being directed straight forward) are perceived opposite the outer parts of the retina, whereas opposite the inner, upper, and lower portions not only can the movements be recognized, but also the number of fingers held up.

The peripheral portions of the retina above and below the yellow spot become impaired next, those inwards and slightly upwards last. The movements of the hand, placed outwards and below the eye (i. e. opposite the inner and the upper parts of the retina), are often recognized while the rest of the retina is completely paralysed. It is very rare to find those peripheral parts of the retina, which are to the inner side of the yellow spot, impaired first, as is often the case in amblyopia from cerebral changes. The upper half of the retina may however be paralysed while the yellow spot and the lower half remain sensitive for a considerable time.

The latter form of impairment of vision by some is termed hemiopia, while the other forms are described as contractions of the field of vision.

The contraction is slit-shaped if the still sensitive portion of retina has a somewhat oval figure with the long axis of the oval placed horizontally.

As regards the efficacy of iridectomy with reference to vision in glaucoma, it has been found that, as a rule, no favourable result is obtained if previous to the operation the paralysis of the retina has extended from the ora serrata to near the yellow spot, more especially if the latter has been situated close to one of the margins of the paralysed part, and if at the same time the optic disc has been much cupped.

The results have been better if the yellow spot has been at an equal distance from the surrounding paralysed or impaired portions of retina, or if much of the impairment of vision could be explained by the turbid condition of the contents of the aqueous and vitreous chambers. A good result has been obtained by the operation if in the intervals between the attacks vision has been but little impaired. The less the optic disc is altered, and the less the peripheral parts of the retina are impaired, the better is the prognosis.

General Remarks.

Glaucoma occurs most frequently between the ages of fifty and sixty, but it has been observed between those of seven and forty. In a case aged seven, simple glaucoma of both eyes, and in another, aged ten, acute glaucoma of both eyes, occurred. Glaucoma, like senile cataract, always appears in both eyes, but rarely with equal severity, or simultaneously.

In one case nineteen years elapsed before the second eye became glau-

comatous. Glaucoma is more frequent in females (80 out of 133 cases), and appears by preference soon after cessation of menstruation.

In some families it seems hereditary, and undue hardness of the eye in other members of the same family is often observed.

Glaucomatous persons frequently suffer from "severe bilious attacks with sickness," from so-called rheumatism in the head, from sleeplessness, and from great prostration and dizziness.

Simple glaucoma occurs seemingly by preference in persons with a large, full, and hard radial pulse.

Attacks of erysipelas often precede chronic glaucoma.

Atheromatous changes in the cerebral and in the ophthalmic arteries have repeatedly been observed after death in glaucomatous persons.

In myopic persons, when suffering from glaucoma, the increase of tension and the attacks of inflammation are less marked. The analysis of a series of cases, in which the ages varied from 14 to 50 (five being below 30), shows that the degree of myopia may vary from $\frac{1}{8}$ to $\frac{1}{2}$. The tension of the eyeball was found nearly normal in two, and but slightly increased in the other cases. Only in one case was there extensive atrophy of the choroid. In all the optic disc was deeply cupped. In all both eyes were affected, but in different degrees. Those not operated upon, lost vision; whereas those who were early operated upon, did well. In all cases the pigmentation of the choroid became very conspicuous round the optic disc, while previous to iridectomy in most a crescent had been the only sign of choroidal atrophy.

Hypermetropia is observed in a large majority of the cases.

Glaucomatous changes, i. e. undue increase of tension with its consequences, are of frequent occurrence after operations. They have been observed after operations for cataract (particularly after depression), and also after spontaneous dislocation of the lens, after injuries (traumatic cataract), adhesions of the iris to the cornea or to a cicatrix, and after intraocular tumour.

Careful attention should be paid in such cases to the tension of the eyeball, the state of vision, and the sensibility of the peripheral parts of the retina, so that the necessary steps may be taken in time to remove the abnormal tension.

Treatment.

Numerous surgical and medical means have been made use of in the treatment of glaucoma. Local or general bleeding, mercury, opium, &c., may seem to have checked "the disease;" or several attacks of inflammation may have passed off spontaneously, and left vision but little impaired; but it has been found that, if glaucoma be left to itself, or be

treated medically only, or by inefficient surgical means, or at too late a period, that vision sooner or later is destroyed.

Tapping of the aqueous chamber, and frequent instillation of a strong solution of atropia, afford temporary relief. When once the tension has increased to a certain extent, atropia seems no longer to pass into the eye.

Most oculists have adopted the operation of iridectomy as a remedy which, in numerous cases, has the effect of diminishing the abnormal tension of the eyeball. Every medical man should learn to perform this operation. In cases of acute glaucoma, where it is of the greatest service, and where immediate surgical aid is required, the difficulties of its performance are but few, for the textures of the eyeball are little altered, provided vision has been useful before the attack.

The operation is more difficult if the textures are rotten, as in simple and chronic glaucoma with much impairment of vision. The removal of a portion of iris is in itself a most harmless step, and never followed by serious consequences. No excuse exists for not performing the operation in acute glaucoma, especially if vision has been good before the attack.

Persons who suffer from glaucoma, and whose sight is but little impaired, must be acquainted with the usual course of "the disease," and with its more serious symptoms. Patients should avoid those things which cause irritation of the eyes, such as much reading, "near-work," mental excitement, sleepless nights, &c. We should urge the operation of iridectomy if we find the peripheral parts of the retina already impaired, or if attacks of dimness, with increased tension, appear at short intervals.

Patients who have lost one eye by glaucoma are more readily induced to have the operation performed.

The longer the operation is postponed the less favourable is the result.

Secondary changes (mostly of an atrophic character) in the structures of the eye, brought on by long-continued pressure, are not remedied by iridectomy.

Accidents which may arise during the operation, such as hæmorrhage into the retina, wounding of the crystalline lens, loss of vitreous, &c., diminish much the chances of success.

As the result of careful examination of the retina, before and from six to eighteen months after iridectomy, properly performed, the following conclusions have been arrived at:

(1.) That the operation may be recommended as long as there is perception of light; and, in acute glaucoma, even if perception of light has been lost for a week after the attack.

(2.) That the usual causes of failure are—advanced structural changes of the optic nerve and of the retina; fresh increase of tension; hæmorrhage, especially in the region of the yellow spot, or into the optic disc; and

accidents during or immediately after the operation, as intraocular hæmorrhage, &c.

(3.) That in the majority of cases the amount of vision is preserved which the patient had before the operation, and that for months vision continues to improve.

(4.) That the result is the less favourable the more the paralysis of the retina has approached the yellow spot, especially if it has done so more from above and below ; or if the sensibility of the region of the yellow spot is so much diminished that the patient, when looking at an object, turns the eye to one side ("eccentric fixation").

(5.) That if we find the aqueous humour turbid, the transparency of the vitreous substance impaired, and the entire retina sensitive, a better result is obtained by iridectomy than if these are clear with a similar amount of impairment of vision.

(6.) That in acute glaucoma the pain ceases almost immediately. (From four to six leeches should be applied at bed-time to the corresponding temple, if the pain returns soon after the operation.) The external "inflammation" and the turbid state of the media, as a rule, disappear after from ten to fifteen days.

(7.) That the less the eyes are used for near-work the more satisfactory and lasting is the result of iridectomy.

For the changes which the various structures undergo after the operation, see above—cornea, iris, optic nerve, &c., &c., in glaucoma.

The pain, attributed to pressure upon the ciliary nerves, is felt in the eye and over the corresponding side of the forehead and temple, sometimes extending into the nose and teeth.

It may be so severe as to deprive the patient of sleep and appetite for days. It is rare in simple, intermittent in chronic, and sudden as well as sharp in acute, glaucoma. In the latter the eye in the ciliary region is tender to the touch. Pain may appear with equal severity in blind glaucomatous eyes. It has been arrested for a time, by injecting from $\frac{1}{8}$ to $\frac{1}{3}$ of a grain of morphia beneath the skin of the temple. It generally ceases at once after iridectomy.

Blind glaucomatous eyes, if painful, should be excised.

THE OPERATION FOR ARTIFICIAL PUPIL AND THE OPERATION OF IRIDECTOMY.

The object of the operation for artificial pupil is to establish a new pupil.

The operation differs from "Iridectomy" in the smaller quantity of iris removed, and in its object being merely to improve vision, whilst that of iridectomy is to influence the tension and nutrition of the eye.

The operation for artificial pupil may be performed on one or both eyes, provided there be sufficient perception of light, no iritis, and no increase of tension.

The Operation for Artificial Pupil is indicated—

(1.) In dense opacity of the cornea with or without synechiæ.
(2.) In closed pupil with or without synechiæ.
(3.) In lateral displacement of the crystalline lens, where its margin interferes with the functions of the natural pupil.
(4.) In stationary opacities of the crystalline lens or of its capsule.
(5.) In obstinate myosis.

The Operation of Iridectomy is performed on one or both eyes—

(1.) In suppuration of the cornea, especially if at a future period, on account of opacity, an artificial pupil might be required, or if otherwise paracentesis might have been performed.
(2.) In some forms of chronic iritis, choroiditis, or ophthalmitis.
(3.) For the removal of foreign bodies from the interior of the eye.
(4.) To relieve the irritation caused by swollen particles of the crystalline lens.
(5.) Preliminary to extraction of cataract, especially if synechiæ exist; or after extraction, if the iris has been much bruised.
(6.) In various forms of staphyloma.
(7.) In hæmorrhage into the vitreous chamber.
(8.) In glaucoma.

Artificial Pupil.

As regards the advisability of the operation for artificial pupil, if the fellow eye is sound, it must be remarked that an enlargement of the field of vision is frequently the sole advantage obtained.

The artificial pupil should be made as small, central, and well-defined as possible, and behind the most transparent portion of the cornea, and that which is least altered in curvature. A careful examination by lateral illumination of the curvature and transparency of the cornea, of the appearance of the natural pupil, and of the state of vision, must precede the operation.

During the operation we act on the supposition of the crystalline lens being transparent. If we find it opaque we enlarge the incision in the cornea, remove more iris, and extract the opaque lens with the scoop, hook, or syringe, or break it up with the needle, and allow it to become absorbed. If it has been removed and the pupil has become closed afterwards, we proceed as stated below.

On the day preceding the operation atropia is applied to the conjunctiva of the eye we wish to operate upon.

Chloroform must be administered in most cases, unless the patient be very quiet, and no complications are expected during the operation.

The Operation.

The patient is placed upon a bed, with the head slightly raised. The operator, standing behind, introduces the stop speculum, to keep open the eyelids to the desired extent, and fixes the eyeball with the forceps, if possible, taking hold opposite the point where he proposes making an incision. The incision is made with a cataract knife or with one of the straight or bent lancet-shaped knives, by passing the instrument slowly through the cornea or sclerotic into the anterior chamber, holding the blade as nearly as possible parallel with the anterior surface of the iris.

The width of the incision depends upon the kind of operation we wish to adopt.

A very small incision suffices if we propose using the iris hook or the canula forceps. A larger incision is necessary for the use of the iris forceps.

Having obtained an incision of the proper width, we slowly withdraw the knife, when, from the escape of aqueous humour, and from the advance of the iris towards the cornea, we infer that the incision leads into the anterior chamber.

We now proceed to the formation of the artificial pupil.

Methods of "making" an Artificial Pupil.

(1.) *By Corepalinanoixis*, that is, by reopening the natural pupil by removing any opaque membrane from its area, that may have remained there, e. g. after iritis.

Excellent results have been obtained by this operation, which, if the crystalline lens is not wounded, and the opaque membrane is but loosely attached to its capsule, admits of restoring, as regards position, the original pupil. The opening into the anterior chamber is made with the smallest lancet-shaped knife through the sclerotic near the cornea. The point of the knife, if the entire margin of the pupil is adherent, is thrust through the iris, behind that portion of its margin which lies farthest from the incision in the sclerotic.

Having thus made an opening to allow of the iris hook being carried behind the iris, the knife is quickly withdrawn so as to lose but little aqueous humour. The hook is then introduced, and its short bent portion carried through the artificially made, or through an already existing, opening behind the margin of the pupil. The short portion of the hook, being turned towards the crystalline lens, is made to glide behind the opaque membrane,

which, on withdrawing the hook gently, may be seen following in its wake. The membrane, which is generally elastic, need not be drawn out of the anterior chamber, but may be detached from the greater part of the margin, and from the area of the pupil, and left to itself. We should select another mode of operating, if after one or two attempts we do not succeed in passing the hook behind the membrane.

(2.) *By Corelysis,* i. e. by separating adhesions of the iris from the anterior surface of the capsule of the crystalline lens. The pupil must be thoroughly under the influence of atropia.

The incision is made in a part through which the largest number of synechiæ can be reached. The instrument, after having made the opening large enough to admit a spatula or iris hook, should be withdrawn quickly, to avoid losing aqueous humour; for the less is lost the more effectual are the movements of the hook or spatula.

To detach the adhesions we pass a blunt iris hook or a spatula close to an adhesion behind a not adherent part of the margin of the pupil; or, if the entire margin be adherent, behind a portion which previously has been separated from the capsule of the crystalline lens, as is done in Corepalinanoixis.

The instrument is then carried on behind the iris until it is supposed to have passed beyond the adhesion or adhesions.

By a to and fro movement with the hook or spatula behind, and as parallel as possible with the iris (so as not to wound the capsule of the lens), and thence through the pupil into the anterior chamber, we detach some or all of the adhesions from the capsule. A more or less circular, active, and clear pupil is frequently obtained.

(3.) *By Iridectomeenkleysis,* in other words, by cutting off part of the iris, leaving part entangled in the corneal incision.

(4.) *By Iridodialysis,* i. e. by tearing away the iris from its insertion.

A sharp hook (or an iris forceps) is introduced through an incision in the cornea up to the insertion of the iris, a portion of which is seized and torn away from its insertion. The entire iris can in this way be readily removed. A pupil is thus formed close to the margin of the cornea.

The incision through the cornea, or through the opaque substance occupying its place, should be made at a spot through which the instruments, used for removal of the iris, can easily reach the insertion of the iris.

This mode of operating has been found of use in cases in which only a narrow rim of cornea has remained transparent; and in cases in which it has been desirable to diminish the tension of the eyeball without removing any iris.

(5.) *By making an incision through a portion of the iris without removing any.* This method has been employed in cases in which a great part of the

iris along with the pupil has been adherent to the cornea, or to a cicatrix which has occupied its place, the crystalline lens being absent or opaque.

The incision is made by thrusting the small or middle-sized lancet-shaped knife through the cornea or cicatrix near the part of the iris we wish to divide, and then into and through the iris. The stretched fibres of the iris are expected to recede from the line of incision. This operation is also employed in cases in which, after absorption or removal of the crystalline lens, the iris has become adherent to parts (capsule, hyaloid fossa, &c.) which are themselves thickened and opaque.

In such cases an artificial pupil, when made in any other way, frequently becomes closed again; whereas extraction with the hook or forceps of the opaque parts may be followed by destructive inflammation.

In these cases a middle-sized lancet-shaped knife is thrust through the cornea near its margin, and through the adjacent iris into the vitreous chamber. The knife is withdrawn quickly so as to lose as little fluid from the vitreous chamber as possible, and a pair of iris scissors is introduced, closed, through the incision in the cornea. Arrived in the anterior chamber, the blades of the scissors are opened—one to pass through the incision behind the iris and behind the parts adherent to it into the vitreous chamber, and the other to glide along the surface of the iris across the anterior chamber. The blades are then closed, and the largest possible incision made through the parts between the blades.

Useful vision has been obtained by this mode where other methods had failed.

(6.) *By Iridodesis or Iridesis*—i. e. by tying with silk a portion of the iris, after having drawn it through an incision in the cornea or sclerotic.

The operation has been performed in cases in which the natural pupil has been entirely or in part preserved.

An incision, just large enough to admit a very small iris hook or canula forceps, is made through the margin of the cornea or through the sclerotic into the anterior chamber (too large an incision may allow the loop of silk, together with the included iris, to slip into the anterior chamber).

A small loop, made of a piece of very fine black silk thread, is laid upon the eyeball round the incision in such a manner that each end of the loop can readily be grasped with ciliary forceps by an assistant.

The small iris hook (which is more manageable than the canula forceps and less likely to bruise the iris) is passed through the loop and incision in the anterior chamber, and the iris which we wish to tie is drawn out through the incision and through the loop. The assistant, in readiness with the ciliary forceps, draws the loop tight as soon as the operator, having withdrawn the desired quantity of iris, directs him to do so. By this means the withdrawn portion of iris is fixed outside the eye. The

assistant, when tightening the loop, should closely follow the curvature of the sclerotic and not draw its ends away from the eyeball. One end of the silk thread is cut short; the other is left about a quarter of an inch long, to allow of withdrawing the loop, which, if it has not fallen off after the eighth day, should be removed.

The advantage of this mode of operating is that the "artificial" pupil retains its contractility. The disadvantages are that a small staphyloma of the conjunctiva, with escape of aqueous humour beneath that membrane, often remains, and also that troublesome iritis occasionally follows.

(7.) *By Coremorphosis*—that is, by excising a small portion of iris.

This is the usual and the easiest mode of "making an artificial pupil."

An incision, sufficiently large to admit of the free passage of the iris hook which we propose to use, is made with a cataract or lancet-shaped knife through the sclerotic close to the margin of the cornea. The iris hook is introduced through the incision, and carried along the posterior surface of the cornea until its short bent part, somewhat turned towards the cornea, has passed beyond the margin of the pupil or the part of the iris we intend to withdraw. Then, by slightly rotating the handle of the hook, we cause the short bent part to turn towards the pupil, without, however, pressing it in that direction.

We now slowly withdraw the hook, which should cause the short bent part to glide behind the margin of the pupil.

Whilst withdrawing the hook, and with it some of the iris, we again rotate the handle so as to cause the short bent part, together with the iris held by it, to turn towards the cornea. This turn we give the hook before its short bent part has reached the margin of the incision, and thus prevent the hook from becoming arrested at that margin. An assistant cuts off the iris which has been withdrawn with a pair of iris scissors, close to the hook if a small, close to the eyeball if a large, pupil is required.

By drawing out the iris more or less we can in a great measure regulate the size of the artificial pupil.

It is preferable, if the margin of the pupil is adherent throughout (as previously ascertained by instillation of atropia), to use, instead of the hook, the iris forceps. The incision in this case must be larger, to admit of easy manipulation of the iris forceps. (See Iridectomy).

IRIDECTOMY.

Instruments.—A thin stop speculum (to keep the eyelids open without stretching the conjunctiva too much, and without causing pressure upon the eyeball). A pair of forceps to fix the eyeball (for this purpose forceps

with sharp points, to enter the sclerotic, are required, if the conjunctiva is so rotten that it tears when grasped).

Straight and angular lancet-shaped knives of different sizes. A pair of iris forceps, a pair of blunt-pointed iris scissors, and a curette.

The Operation.

The patient, placed in a recumbent position with the head slightly raised, is brought thoroughly under the influence of chloroform so as to avoid all straining. The operator, standing behind the patient, introduces the stop speculum to keep the eyelids open to the desired extent.

With the forceps ("to fix the eyeball") he seizes the conjunctiva and subconjunctival tissue (or with the sharp-pointed forceps the sclerotic, if the conjunctiva should tear) close to the margin of the cornea and as nearly as possible opposite the spot where the point of the knife has to enter. Previous to commencing the incision the eyeball should be rotated in various directions so as to ensure its being well secured. The point of the knife is then thrust slowly through the sclerotic into the anterior chamber, just in front of the insertion of the iris, care being taken to keep the point, while in the anterior chamber, directed towards the cornea, so as to avoid wounding the crystalline lens. The knife, having entered the anterior chamber, is carefully pushed on until the incision has the desired size. The width of the cutting blade of the lancet-shaped knife should be such that the desired size of the incision is obtained whilst the knife is advancing into the anterior chamber. The incision, if not wide enough, must be enlarged while withdrawing the knife.

The knife, after completing the incision, is gently withdrawn, its point being kept inclined towards one or the other side of the anterior chamber away from the area of the pupil, so as to avoid wounding the lens and to prevent too rapid escape of the aqueous humour.

If, previous to making the incision, there is little or no aqueous humour, so that the iris nearly touches the cornea, especially if at the same time the pupil is much dilated, and consequently the lens more likely to be injured, then the incision is made with the smallest lancet-shaped knife, and some iris is drawn out with the iris hook and cut off. After a few days a larger quantity of aqueous humour has accumulated, when a larger iridectomy may be performed.

Instead of adopting this proceeding, we may enlarge the small incision with scissors (which is more difficult), and perform iridectomy at once.

Some, to obviate a cystoid cicatrix, commence the incision at the extreme margin of the cornea, thrusting the blade perpendicularly through the cornea, and, on reaching the anterior chamber, pass it on in the usual direction.

Better vision and better outward appearance of the eye is obtained by

making the incision near the upper margin of the cornea. The subsequent steps of the operation are, however, rendered easier by making it near the outer margin.

The operator, after completing the incision, either confides the forceps to the assistant, who seizes and steadies the eyeball, or he does it himself, while the assistant is entrusted with the manipulation of the iris scissors.

The next step is the removal of a portion of the iris. The iris, if protruding from the wound, is seized with the iris forceps close to one of the angles of the incision, and cut off as directed below. If the iris is not protruding, the curved iris forceps are closed and introduced through the centre of the incision, and pushed onwards in front of the iris, and carried up to and not beyond the margin of the pupil, where they are allowed to open to the extent of the incision.

The iris, by pressure of the parts behind, is pushed between the branches of the forceps; it is seized by closing the forceps without pushing them back towards the iris. The latter is then slowly drawn out through the incision, and with the scissors cut through on the side of the forceps close to one angle of the incision, care being taken to divide the iris from the margin of the pupil to its insertion. Having divided the iris at this point, we draw the portion grasped by the forceps towards the other angle of the incision; we thus tear it away from its insertion and again divide it with scissors at the other angle. Before making this second cut care should be taken to draw the iris towards the angle where it was divided first. Adhesions of the iris to the incision are thus avoided.

In this manner we remove the entire width of the iris, or nearly as much as corresponds to the length of the incision in the sclerotic.

The more widely the forceps are opened the more of iris can be seized and excised.

Some are satisfied with the less difficult proceeding of cutting off at once the portion of iris which has been withdrawn with the forceps.

No iris should be left entangled in the incision. A flexible spatula or a scoop may be passed through the incision at its angles, and any iris, that may have remained there, may be pushed back into the anterior chamber, care being taken not to wound the crystalline lens nor its suspensory ligament.

The speculum is then slowly removed; and some lint, dipped in cold water, is tied over the closed eyelids, so as to exercise slight pressure, while the patient is recovering from the effects of the chloroform.

Accidents during the Operation of "Iridectomy," or that for "Artificial Pupil."

Experience is required as regards the distance from the margin of the cornea at which the incision should be made through the sclerotic

By piercing the sclerotic too far from that margin we may be led behind the iris, and wound the lens or some of the ciliary processes, or with the point of the knife tear the iris from its insertion.

The former accident has been followed by cataract or by loss of "vitreous;" the latter by profuse hæmorrhage into the chambers and beneath the conjunctiva.

Bleeding into the anterior chamber.

(1.) Through wounding the ciliary processes, or detaching the iris from its insertion. This accident may happen if the knife, entering through the sclerotic, is introduced too far from the margin of the cornea, or is not properly directed.

The bleeding may be so profuse as to oblige us to discontinue the operation. Severe traumatic iritis may follow. The point of the curette should be kept in the wound, and slight pressure made upon the eye, to encourage the escape of blood. If this does not succeed in removing the blood, it is better to postpone the other steps of the operation until all blood has become absorbed.

(2.) Through blood running into the anterior chamber from cut vessels of the conjunctiva. This often occurs in eyes in which the tension is below par, or in which, from protracted extensive inflammation of the choroid and iris, with normal tension and generally with total posterior synechia, the textures have lost their elasticity. To recognize such eyes experience is required.

It is generally useless to attempt to remove the blood. Slight pressure, by means of wet lint tied over the closed eyelids, causes it to become more rapidly absorbed.

The incision should be made in such cases through the cornea, and the operation conducted in a manner to avoid as far as possible all sources of bleeding.

(3.) Through spontaneous bleeding from the iris.

This occurs more frequently if there is chronic iritis, or if the blood-vessels of the iris, after protracted iritis, have lost their elasticity. We sometimes succeed in removing the blood (if fluid) by suction, or by pressing upon the cornea with the finger or curette, or (if clotted) by drawing out the clot with the iris forceps. Clots of blood, if left, sometimes set up new iritis, and occasionally closure of the artificial pupil.

Pressure upon the closed lids, by means of wet lint, should be made until all blood has disappeared.

The aqueous humour may escape before the incision is completed, i. e. before it has the desired width.

The knife should be withdrawn, and the incision completed with blunt-pointed (strabismus) scissors, taking care to carry the point of that blade

of the scissors, which is introduced into the anterior chamber, close along the insertion of the iris. An incision may thus be enlarged to any extent.

Some difficulty may be experienced in the introduction of the iris hook or of the iris forceps. If the incision has been made through the sclerotic, very slight pressure with the instrument upon the sclerotic next the margin of the incision which is farthest from the cornea will cause the incision to gape, and thus generally allow the instruments to pass. Occasionally some conjunctiva may have to be excised, or the incision may have to be enlarged, or even a second incision may have to be made through or near the cornea.

We may not succeed with the iris hook in drawing out the iris, through the texture of the iris being so rotten, that the hook passes through it, as it would through wet blotting-paper. In this case we enlarge the incision and remove the iris with the forceps.

The same proceeding is adopted if the margin of the pupil is adherent throughout, causing the short part of the hook to glide from the area of the pupil over its margin instead of behind it.

Difficulties in the removal of iris with the iris forceps may arise through the texture of the iris being so altered by inflammation, that it has become stiff and often glazed over with transparent exudation, or adherent throughout to the capsule of the lens, so that it cannot be grasped by the forceps. In this case a lancet-shaped knife is thrust, close to the incision in the sclerotic or cornea, through and behind the iris into the crystalline lens. A square-shaped piece of iris and lens capsule is grasped with the iris forceps (one of the branches being passed through the incision behind the iris into the lens, the other in front of the iris) and torn away ; or a piece of the iris and capsule are cut out with iris scissors. This step is followed by the removal of the crystalline lens. A similar proceeding is adopted if the iris, on account of its being too rotten, can only be removed in small particles, while the uvea remains adherent to the capsule of the lens.

Adhesion of the uvea to the capsule of the lens is the rule if extensive iritis has preceded the operation. The excised portion of iris should therefore be placed in water and examined for the presence of the uvea ; and if no bleeding has ensued at the time of the operation, lateral illumination should be used, by which means, in every case, the presence of uvea in the area of the artificial pupil can be discovered.

The uvea during lateral illumination may be scraped away with a spatula from the capsule of the lens. The treatment generally adopted, however, is to remove the capsule of the lens with the uvea attached to it, and then the lens itself.

Causes of failure, or of incomplete success, of the Operation for Artificial Pupil.

(1.) Opacities and alterations in curvature of the cornea (which may

only become conspicuous after the operation); (2.) Pigment on the capsule of the crystalline lens; (3.) Cataract; (4.) Alterations in the shape of the eyeball; and (5.) Morbid changes of the choroid and of the other tunics.

1, 2, and 3 can, as a rule, be discovered by lateral illumination; 4 and 5 by the use of the ophthalmoscope.

(6.) Hæmorrhage into the anterior chamber. In this case considerable time must be allowed to pass before attempting a second operation. All inclination of the eye to "redden up," and all discolouration of the aqueous humour, should have disappeared before operating again. During the steps of a second operation all things should be carefully avoided which had given rise to bleeding before, e. g. an incision through the sclerotic, straining during the operation, wounding of certain portions of iris, &c.

A combination of several of the causes of failure of the operation is frequent, and often renders the treatment after the operation difficult. (See the treatment of Opacity of the Cornea, Cataract, &c.)

Iritis attributable to the operation itself is a rare occurrence; probably owing to the fact of the piece of iris, seized with hook or forceps, being removed, and to the iris tissue, which is generally altered in structure, being less susceptible of inflammation.

(7.) *A so-called cystoid cicatrix,* i. e. an incision which has become incompletely closed by loose opaque tissue, allowing the aqueous humour to escape beneath the conjunctiva: this gives the latter an œdematous appearance. In extreme cases the aqueous humour may extend beneath the conjunctiva all around the cornea; whereas in slight cases there may be mere bulging of the intervening tissue between the margins of the incision. The cystoid cicatrix frequently occurs after the operation of iridesis and after iridectomy, if the incision has been made through the sclerotic, and if some of the iris has remained entangled in the incision, or if increased tension has caused expansion of the tissue filling the incision. Generally no harm results, but suppurative iritis has been known to follow.

The local application of atropia, gentle pressure by means of a bandage applied over the closed eyelids, or puncturing the bulging cicatrix with a broad needle, has been recommended.

The bulging of the conjunctiva, if troublesome, or disfiguring the appearance of the eye, may readily be removed, and the cystoid cicatrix closed by passing a silk thread through the sclerotic across the point through which the aqueous humour seems to escape. The thread is tied tightly, the ends are cut short, and the lids kept closed until the thread has come away spontaneously. The inflammation, caused by the presence of the thread, suffices to close the opening which leads into the aqueous chamber.

Closure or contraction of the artificial pupil is observed, (1.) In eyes with

total posterior synechia; (2.) In eyeballs which are more or less shrunken, and the tension of which is below par.

Vision after the Operation for Artificial Pupil.

We may obtain binocular vision (the most favourable result) by most of the various modes of operating; if the retina is sound in the region of the yellow spot, and the artificial pupil not too near the margin of the cornea.

Strabismus may follow from non-use of the eye operated upon.

Sometimes diplopia occurs, which disappears either spontaneously through both eyes acting together, or through the less distinct retinal image of the eye operated upon being no longer observed.

CHAPTER XI.

THE RETINA AND THE OPTIC NERVE.

THE RETINA.

ANATOMICAL AND GENERAL REMARKS.

The retina is spread out between the choroid and the vitreous substance, and extends from the optic disc to the ora serrata. It is thickest (measuring about $\frac{1}{9}$ of an inch) at a short distance from the yellow spot. As it approaches the ora serrata it gradually becomes thinner, through decrease in the number of its component parts. Its thickness, half an inch outwards from the yellow spot, is about ·00059 inch.

The retina is firmly attached along the ora serrata and round the optic disc, but only loosely to the surface of the choroid. The opening in the retina through which the optic nerve has to pass is termed "*the retinal aperture;*" and the optic nerve at this spot is termed the optic disc, or *the blind spot.*

The region of *the yellow spot* lies to the outer or temporal side of the optic disc. In this region we distinguish the centre or "centre of the retina" (by some termed "the fovea centralis"). The colour of the region of the yellow spot differs from that of its centre, as well as from that of all other parts of the retina.

The serrated line of attachment of the retina along the ora serrata is termed "*the margin,*" or "*periphery of the retina.*"

We further distinguish between the "inner surface" of the retina, which faces the vitreous chamber, and the outer surface, which is next the choroid.

Colour of the retina when viewed with the ophthalmoscope.

In fair persons the retina appears transparent; in those with brown irides very faintly greyish; and in those with dark eyes of a bluish tint. This tint decreases from the optic disc towards the ora serrata, and is

attributed partly to the pigmentation of the choroid, and partly to the light which is reflected from the layer of optic nerve fibres, which in dark eyes gives the surface at the retinal aperture a delicately-striated appearance.

A peculiar colour is observed in most healthy eyes in *the region of the yellow spot.* This region, as regards colour, has a transversely oval shape, with the long axis of the oval horizontal.

The centre, looked upon as the most sensitive part of the retina, lies about $\frac{3}{16}$ of an inch from the middle of the optic disc, and on a level with its upper margin. In eyes with light blue irides this region often differs but little from the rest of the retina; but sometimes a greyish halo, surrounding a reddish minute dot (the centre) of about $\frac{1}{16}$ of an inch in diameter, is observed. (See Plate VI. Figs. 4, 5, 6.) In eyes with brown irides, and still more in those with black irides, the centre appears as a dark spot, surrounded by a greyish-yellow halo, and the latter by a greyish semitransparent one, which shades off into the transparent retina.

The retinal Blood-vessels. (See Plate V. Figs. 1, 2, 3.)

The blood-vessels of the retina enter and leave the eye by passing through the optic disc. Within the eye they do not anastomose with those of the other tunics. All the blood which goes to and comes from the retina has to pass through the optic disc. The walls of the vessels appear transparent. Several of the arteries subdivide in the optic disc before reaching the retinal aperture. Thus, from near the middle of the optic disc two large branches pass upwards, and two downwards into the retina across the optic nerve fibres. In the retina, close to the optic disc, they subdivide into smaller branches, a large number of which turn towards the region of the yellow spot. The arteries break up into capillaries. Besides the larger trunks there are many small vessels which enter and leave the retina, on the right and left of the retinal aperture.

In young persons sometimes three or four arteries, and as many veins, can be seen passing through the optic disc. In middle-aged persons generally only one or two large arteries can be observed. The apparent number decreases as age advances. The greater number of vessels are observed in the outer or temporal part of the retina. Peculiar twistings of the arteries are often seen, especially in the optic disc.

The veins which return from the retina also pass through the optic disc; they run near the arteries.

The arteries can be distinguished by their bright red colour and straight course. They are thinner, and not unfrequently present a double contour, i. e. the blood seems to glide along the sides, while the central parts of the vessels appear empty. This is due to light being reflected from this part of the vessels. The veins are darker, more numerous, larger,

and more variable in diameter. They are readily distinguished from the arteries by pressing gently upon the eyeball with the finger while examining with the ophthalmoscope; the pulsation of the arteries in the optic disc then becomes at once apparent.

Pulsation of the retinal blood-vessels.—The relations between the vitreous substance and the blood circulating in the retina are such, that the slightest pressure upon the blood-vessels becomes apparent, especially in the optic disc. It causes, if at all considerable, visible pulsation of the arteries and a peculiar undulation of blood in the veins, which latter is also termed a pulsation. Large flat veins, tapering off as they leave the optic disc, show this undulation of blood best. It consists in an irregular filling of some and emptying of other parts of the veins. The contraction of the vein advances from the centre towards the margin of the optic disc, while the dilatation commences at the margin. A short pause intervenes between the maximum of dilatation and the commencement of contraction. All movements of the eye, all efforts at accommodation for near objects, and many changes in the respiration, cause increase of the venous pulse.

The blood, thrown into the retinal arteries with every systole, has to pass through the capillaries to reach the veins. The arteries momentarily become dilated, and the quantity of blood in the eye is increased. The vitreous substance during this movement is pressed upon, and, in its turn, presses upon the optic disc and its blood-vessels.

This pressure becomes perceptible in the veins in the optic disc. The veins become flattened out, before the quantity of arterial blood, which causes the increased pressure, has reached them. The current of blood in the veins is lessened until the pressure of the arterial blood (during the systole) has reached them through the capillaries. The systole having passed, the pressure of the vitreous substance becomes lessened, the veins become still more dilated, and the blood readily escapes from the eye. The circulation in the capillaries is never interrupted.

The pulsation of the retinal arteries in the optic disc is not visible under ordinary circumstances. In rare instances it occurs spontaneously, and appears due to a peculiar arrangement of the vessels. Artificial pressure upon the eyeball, or a morbidly increased tension, is required to render it visible. A brisk filling and emptying of the arteries in the optic disc, synchronous with the pulse, is observed when gentle pressure is made upon the eyeball. The retinal arteries are thus pressed upon the margins of the sclerotic and choroidal apertures, beyond which apertures the visible pulsation does not extend. An entire displacement of the blood from the arteries, with cessation of the pulse, occurs when the pressure is greatly increased.

The minute structure of the Retina. (See Plate I. Figs. 1, 2.)

On examining the inner surface of the retina, when fresh, with the

microscope, we observe except over the yellow spot faint delicate lines radiating from the optic disc. These are the bundles of optic nerve fibres. Beneath and among these we see the blood-vessels, and deeper still an agglomeration of granules. When the retina is viewed on the outer surface we perceive the rods and bulbs which occupy this entire surface, and beyond these we see again an agglomeration of granules.

In sections through the entire thickness of the retina, made about midway between the optic disc and the yellow spot, and parallel with the optic nerve fibres, we observe a variety of structures, which are piled upon and connected with each other, and most of which appear arranged in layers. These, commencing from the inner surface, i. e. with the optic nerve-fibres, are—

(1.) The layer of optic nerve fibres.

(2.) The layer of ganglionic cells—"the ganglionic layer"—in which is found the larger number of blood-vessels.

(3.) The granular layer.

(4.) The inner granule layer.

(5.) The inter-granule layer.

(6.) The outer granule layer.

(7.) The layer of rods and bulbs,—"the bacillary layer,"—or Jacob's membrane.

(8.) Intervening between (6) and (7) is a transparent line of demarcation, into which many of the rods are inserted, and from which many fibres start, to pass through the retina in a direction perpendicular to that of the optic nerve fibres. This line by some is termed the "outer membrana limitans," and is described as a separate layer.

A similar line of demarcation (a transparent membrane, when viewed from the surface) is seen upon the layer of optic nerve fibres (intervening between them and the hyaloid membrane). This is the structure into which the fibres ("radial fibres") are inserted. Some describe it as a separate layer; it is termed the inner membrana limitans; and the fibres inserted into it may be regarded as the connective tissue of the retina.

(1.) The layer of optic nerve fibres.—These fibres, having arrived at the upper margin of the retinal aperture, pass from the optic disc on to the inner surface of the retina. The layer is thickest at this part, and gradually becomes thinner the nearer it approaches the periphery of the retina. Those fibres which lie nearest the surface of the retina enter into it, and, judging from the examination of numerous sections, anastomose with the ganglion cells.

(2.) The layer of ganglion cells.—The cells are large, vary in size, are multipolar, with several nuclei, and are placed at definite distances from each other. Some proportion seems to exist between their number and size and the thickness of the retina. The thinner the retina the more distant

are they from each other. They are on a level with the large blood-vessels. The centre of the yellow spot, where it is on a level with this layer, is occupied by a cluster of nucleated cells, which are somewhat larger than the granules.

(3.) The granular layer around and beneath the ganglion cells is an exceedingly delicate layer, and is well supplied by capillaries. Little is known as regards its minute structure.

(4.) The inner granule layer consists of cells, which, on the application of a weak solution of chromic acid, show two or three nuclei. The granules are round, and separated from each other by connective tissue; they are piled upon each other in a certain order, and decrease in number towards the periphery of the retina.

(5.) The inter-granule layer consists of delicate fibres, many of which belong to the connective tissue, and pass through the retina from one layer of granules to the other. Numerous very fine fibres, running at right angles to the former, i. e. parallel with the layer of nerve fibres, are found in this layer, especially at and near the retinal aperture.

(6.) The outer granule layer.—The granules of this layer are, when fresh, transparent; some are round, others oval, resembling pus cells after having been exposed to chromic acid. Many appear, when fresh, striped transversely, one or two dark parallel lines being perceptible on their surface. The granules are piled upon each other, and lie free in the connective tissue; they decrease in number from near the centre towards the periphery of the retina. Each granule is separated from its neighbour by one filament of "connective tissue."

(7.) The layer of rods and bulbs.—The elements of this layer in the region of the yellow spot are termed bulbs; they are larger than the rods, and smaller than the bulbs in other parts of the retina, and are of equal size, standing side by side and perpendicularly upon the granules of the hexagonal cells of the choroid. Further from the yellow spot we find the narrow transparent rods, and among these, at distances which increase from the yellow spot towards the periphery, the somewhat pear-shaped bulbs. There seem to be two kinds of rods: those which cannot be traced beyond the outer membrana limitans; and those which can be traced into the retina, many of which seem to be continuations of the fibres of the connective tissue.

The connective tissue of the retina, see Plate I. Figs. 1, 2, "its framework," "the radial fibres."—This tissue consists of delicate nucleated fibres (somewhat thicker than nerve fibres), which run across the retina and anastomose freely with each other through the medium of filaments, and enclose within their anastomoses the granules, &c., of the retina. On reaching the layer of nerve fibres many are seen to split up into smaller fibres, which diverge from each other; and, after having passed across this layer,

are seen to insert themselves ("open out") into the inner membrana limitans. A similar insertion is found at the so-called outer membrana limitans. The relation of these fibres to the rods and bulbs is not well understood; many of the rods seem to be continuations of these fibres. The fibres of the connective tissue intervene between the elements of the retina and the optic nerve fibres at the retinal aperture, and likewise separate these elements from the zonula along the ora serrata.

In the region of the yellow spot the fibres of the connective tissue have a peculiar course. Here, after having advanced perpendicularly into the retina for some distance, enclosing the granules of the outer granule layer (in piles of generally four granules), they assume a wavy (undulating) course; those at the centre of the yellow spot pass directly towards the inner membrana limitans, while those adjoining them pass off at an angle, and run obliquely through the retina. Having for some distance continued their wavy slanting course, they again ascend perpendicularly, to reach the inner membrana limitans. These wavy fibres intervene between the outer and inner granule layers.

The connective tissue and the outer and inner granule layers are the most durable structures of the retina, while the layer of ganglion cells and the granular layer seem most susceptible of destruction.

THE OPTIC NERVE. (ON.)

GENERAL AND ANATOMICAL REMARKS.

Some of the terms, which are used to distinguish the different parts of the optic nerves outside the eye, the peculiarities of the nerves at the chiasma, and their course within the cranium, are treated of under Hemiopia.

The cerebral origin of the optic nerve fibres, and their relations to other parts of the brain and spinal cord, are not known. Some of the optic nerve fibres are supposed to pass beyond the corpora geniculata and tubercula quadrigemina to the cerebral convolutions.

We shall in this place treat of what is termed the optic disc, and shall treat of the optic nerve while forming part of the retina under Retina.

The portion of the optic nerve which passes through the tunics of the eyeball, and which can be seen with the ophthalmoscope, has been termed by some *the optic nerve entrance,* or the *optic papilla;* we shall describe it as the *optic disc.*

The optic nerve within the orbit is enclosed within a sheath. This sheath (by some termed the outer sheath) consists of fibrous mixed with elastic tissue. The sheath is firmly attached to the sclerotic; the

fibres merging into those of the outer two-thirds of the sclerotic aperture (i.e. of the opening in the sclerotic through which the optic nerve has to pass).

Loose filaments of connective tissue pass between the sheath and the optic nerve, thus allowing of a limited movement of the nerve within the sheath.

The fibrous tissue, generally termed connective tissue, which immediately surrounds the optic nerve, is *white and opaque outside the eyeball, semiopaque on a level with the inner third of the sclerotic, and transparent in the choroidal and retinal apertures and in the retina.*

Its fibres, examined microscopically, show a circular course at the surface and near the middle of the nerve.

Those at the surface, *the outer circular fibres,* have by some been termed the inner sheath of the optic nerve. Large fasciculi of fibres separate the bundles of nerve fibres from each other, and single fibres intervene between the several individual nerve fibres.

The greater bulk of the optic nerve consists of this fibrous or connective tissue, which gradually becomes less in quantity and altered in colour as it advances with the nerve fibres within the sclerotic aperture. The connective tissue, which extends across the choroidal aperture (at the point where the sclerotic and choroidal apertures meet) is termed *the fascia cribrosa.*

Arrived on a level with the vascular portion of the choroidal aperture, the circular fibres merge into those of the adjoining sclerotic and choroidal apertures. This is the point of attachment of the connective tissue of the optic nerve. It is at this point that the distension of the myopic eye is most conspicuous.

A network of single transparent nucleated fibres separates the optic nerve fibres from each other in the retinal aperture. The nuclei of the fibres have a regular arrangement, stand close to each other, and can often be traced upon the retina.

The optic nerve fibres within the orbit and in the sclerotic aperture are united into bundles, each bundle being separated from the next by connective tissue, each carrying from six to thirty optic nerve fibres, and each nerve fibre again being separated from the adjoining ones by a filament of connective tissue. Connective tissue (its fibres having a circular arrangement) separates the bundles of nerve fibres from the retinal vessels where these pass through the optic nerve. Similar fibres are found at the outer surface of the nerve. They join the loose connective tissue which intervenes between the optic nerve and its sheath.

The largest bundles of nerve fibres are situated midway between the surface and the middle of the optic nerve.

The optic nerve, as it advances within the tunics of the eyeball, becomes

thinner, not through diminution in the number of its nerve fibres, but through diminution of the surrounding connective tissue. The optic nerve is thinnest in the choroidal aperture.

At the upper margin of the retinal aperture the fibres bend away from the axis of the nerve and pass upon the retina.

The portion of the optic nerve, which in the living subject can be seen with the ophthalmoscope, is termed the optic disc.

In the optic disc we distinguish—

The margin, i. e. the portion which joins the tunics of the eyeball.

The centre, i. e. the point where the larger number of blood-vessels of the retina meet.

The colour.—To see the natural colour the optic disc should be examined with the ophthalmoscope by the direct method. Great varieties in colour are compatible with normal vision.

The disc generally appears of a brilliant transparent pale pink colour, except the part which joins the retinal vessels where they occupy the middle of the disc. This portion, generally, appears grey-white or brilliant white, and may occupy as much as one-fifth of the nerve surface. As a rule it is observed in both optic discs of the same person, but varying in extent.

Examined by the indirect method, the optic disc, especially in "fair" eyes, appears deep pink or red.

A white or bluish-white optic disc has repeatedly been seen in young persons with quite normal vision.

The optic disc consists of transparent, semiopaque, and opaque portions. The opaque portion, together with the blood circulating among the optic nerve fibres, determines the apparent colour of the disc. The nerve fibres are transparent throughout, and the filaments of connective tissue separating the fibres from each other and from the blood-vessels are transparent in the retinal and choroidal apertures. If we describe an optic nerve or an optic disc as anæmic or hyperæmic, &c., we in reality describe the colour of the opaque fibrous tissue in the sclerotic aperture, and the quantity of blood circulating in the optic disc.

The optic disc appears finely dotted with grey minute spots when examined by the direct method and slightly magnified. These spots are the larger bundles of transparent optic nerve fibres emerging from the opaque surrounding tissue. The bundles of nerve fibres, where they radiate from the optic disc over the retina, may in dark persons be visible as faint greyish lines.

The optic disc receives its blood supply from the short posterior ciliary arteries, and from the retinal artery. These arteries anastomose at the choroidal aperture with the capillaries of the choroid. The vascular plexus which surrounds the optic nerve fibres in the disc is the sole means of anastomosis between the choroidal and retinal blood-vessels.

The retinal artery passes into the optic nerve in the orbit about $\frac{3''}{8}$ from the sclerotic. The retinal veins leave it in the orbit, at from $\frac{1''}{8}$ to $\frac{3''}{8}$ from the sclerotic.

The contrast in colour between the disc and the adjoining tunics is the greater the more pigmented the choroid is.

The size of the disc varies according to age. It appears smaller in children, largest in full-grown persons, and becomes smaller again in advanced life.

The shape of the disc as regards outline ("its margin") varies considerably in healthy eyes. In the majority it is nearly circular. In some it appears vertically oval.

Its outline may appear altered through anomalies of the refracting media, and through morbid changes of the tunics at the choroidal and sclerotic apertures. The outline may in reality be altered through disease of the nerve itself. The outline appears best defined in dark eyes.

The optic nerve, to reach the surface of the retina, has to pass through the sclerotic, choroidal, and retinal apertures. Each of these may present peculiarities which lie within the limits of health, but by the superficial observer may be mistaken for irregularities in the outline of the optic disc itself.

The most frequent peculiarities are—

(1.) A white crescentic figure skirting part of the margin of the optic disc, more often the one next the yellow spot. This is generally present in both eyes of the same person.

This is due to the pigment and blood of the choroid not advancing up to the nerve, thus leaving the white sclerotic exposed.

(2.) A fringe of pigment (a black crescent) at any part of the margin of the disc. This is caused by accumulation of pigment in the margin of the choroidal aperture.

Curvature of the surface of the disc.—In health a slight indentation exists at or near the centre of the optic disc at the spot where the nerve fibres bend away from the fibrous tissue which surrounds the blood-vessels.

A glistening white and roundish spot of varying size, and adjoining the trunks of the vessels in the optic disc, often indicates the extent of this tissue which separates the vessels from the bundles of the optic nerve fibres. Vestiges of the arteria centralis are occasionally found at this spot. The optic nerve fibres are confined to the pink portion of the optic disc.

The larger this white portion of the healthy optic disc the wider we suppose the cupped portion of its surface to be. Whether the edges of the cup are abrupt or not, depends upon the bend of the optic nerve fibres. The vessels in this kind of cup appear natural as regards number, size, and course.

A peculiar increase in curvature of the blood-vessels and nerve fibres, especially where these pass over the upper and lower margins of the retinal aperture, is observed in highly hypermetropic persons, particularly in children. It appears as if the optic disc and the adjoining tunics were projecting too much into the vitreous chamber.

Congenital Anomalies.

An anomalous position of the optic disc, compared with that of the disc of the fellow eye, has been observed. The existence of a faulty position has been established by comparing the position of the cornea of the affected eye when its optic disc (examined with the ophthalmoscope) has been in view with the relative position of the cornea and optic disc of the healthy fellow eye when examined in the same manner.

Congenital anomalies in shape and colour of the optic disc occur frequently. They often accompany anomalies in development of other parts of the eye, as seen in Myopia, Coloboma, Mycrophthalmus, and Hypermetropia; others are the result of inflammation during intrauterine life, as observed in inherited syphilis.

Development of the Retina.

Among the peculiarities of the fœtal retina must be noticed—

1. The presence of numerous folds.
2. The fœtal fissure, extending from near the lower margin of the crystalline lens to the nearest point of the optic disc.
3. Peculiarities at the retinal aperture, and at the ora serrata.

(1.) The retina is thrown into folds, which are most numerous about the end of the first month. They project into the vitreous chamber; the larger ones occupy the region of the yellow spot. It is stated that no optic nerve fibres are found upon the folded parts of the retina. The folds disappear (first along the ora serrata) as the eye increases in size, and the retina gradually flattens itself out upon the choroid. About the ninth month some folds may still be found near the lower margin of the optic disc.

(2.) About the beginning of the third month the margins of the fœtal fissure are inverted towards the vitreous chamber; the fissure is broadest near the optic disc, and is closed about the commencement of the fourth month. A narrow seam extending from the optic disc to the ciliary processes, and slightly projecting into the vitreous chamber, indicates the direction occupied by the fissure.

(3.) The retinal aperture (round the optic disc) is very small about the end of the third month. It is not circular, but irregular, some parts of

the retina projecting more towards the optic disc than others. These prominences disappear about the fifth month, when the aperture becomes more round.

About the end of the third month pointed processes appear upon the folded margin of the part of the retina which lies next the crystalline lens. These processes grow forwards towards the margin of the lens, and form part of its suspensory ligament.

About the second month the bulk of the retina consists microscopically of nucleated cells. About the third month the fibres of its connective tissue, and about the fourth month the optic nerve fibres, can be recognized.

Congenital Anomalies.

Absence of all the retinal blood-vessels, with a white atrophic optic disc, and incomplete development as regards number, have occurred repeatedly. There has been amblyopia in the latter and amaurosis in the former cases.

Very thin retinal vessels, with an anæmic optic disc, have been observed in children who have suffered from inherited syphilis.

An opaque white colour of the connective tissue of the optic disc, extending as a pearly-white and opaque band over a limited portion of retina, has repeatedly been seen.

For other anomalies see Coloboma of the Choroid, and also Hypermetropia and Myopia.

Incongruence of the Retina.—Of this anomaly two varieties are described. In the one an excentric part of the retina, i. e. one outwards or inwards from the usual position of the yellow spot, is used when looking at an object directly. The acuteness of vision of the excentric part is greater than that possessed by the region of the yellow spot. Vision of the fellow eye and the relative positions of the different parts of its retina are normal.

In the other variety the yellow spot is stated to be situated on the inner or nasal side of the optic disc.

Development of the Optic Nerve.

The eye at first is in immediate contact with the brain. An opening situated below the posterior pole of the eye leads from the eye into the brain. The eyes and the brain gradually recede from each other. They remain connected by a reddish transparent substance (the optic nerves). The nerve fibres at first consist of globules placed side by side. These finally join each other.

In the optic nerve a fissure (sulcus) occurs, which is continuous with a similar fissure in the tunics of the eye. The fissure in the tunics becomes closed long before the one in the optic nerve, which is still perceptible about

the end of the third month. About the same time some connective tissue, surrounding the central artery, may be seen projecting from the optic disc into the vitreous chamber.

The chiasma of the optic nerves is fully formed about the middle of the third month.

VISION.

An object to be seen with the greatest possible distinctness must have a certain size, be placed in good light, and at a distance which allows the rays which come from it to be brought to a focus in the yellow spot of the retina. A well-defined inverted image of the object is formed at that spot. This image (through the fibres of the optic nerve) must be conveyed to the brain, be perceived there, and again be projected in an inverted direction towards the object. The layer of rods and bulbs is supposed to be the perceptive part of the retina. At the yellow spot (where the most distinct vision takes place) this layer consists of small bulbs, with a few ganglion cells and optic nerve fibres intervening between them and the vitreous chamber. Here the rays of light reach the bulbs more directly than in any other part of the retina. The undulations of the rays of light, by passing through the elements of this layer, produce a change which is termed perception of the object from which the rays have emanated.

The optic nerve fibres convey the impression received from the retina. They themselves do not possess perception of light. This is well known as regards the optic disc or blind spot. That the same applies to the optic nerve fibres upon the retina is inferred from the fact that the shadows of the retinal vessels in our own retinæ can be made visible to ourselves.

To accomplish this in a dark room, we direct the cornea of the eye which we wish to examine towards the nose as much as possible. The image of the flame of a candle or gaslight is then brought to a focus upon the sclerotic by means of a 2-inch or 3-inch convex lens.

To determine the *acuteness of vision* (*V or S=vision or sight*) of an eye, it becomes necessary to ascertain the size of the smallest object which can still be seen distinctly. The smallest angle under which, by the normal eye, an object can be recognized distinctly is one of about five degrees (=5°). For example, take the letter I, which we suppose to be one inch high, its width being equal to one-fifth of its height; place that letter at 50 ft from the normal eye under examination, and let us assume that it can be recognized at that distance and not farther off. To ascertain under what angle the letter is seen, we imagine a straight line to be drawn from the extreme points (i. e. from the upper and lower ends) of the letter to the two corresponding points of its small inverted image in the retina. These lines

cross each other within the eye, and, at the point of crossing, form equal angles. If we measure either of these angles we find it to be an angle of 5°. If the letter is brought nearer, say to a distance of 40 ft or 30 ft, its image on the retina is larger, and the letter therefore can be perceived better, because its image is spread over a larger number of perceptive elements of the retina. If the letter is held farther off than 50 ft, say at 55 ft or 60 ft, it can no longer be perceived distinctly, because the image on the retina is too small. The letter I, held at 50 ft from the eyes, is seen under an angle of 5°. If the letter is held nearer, the angle becomes larger; if it is held farther off, it becomes smaller. The farther from the eye the letter I is held the smaller is its image on the retina, and the smaller the angle formed by the straight lines drawn from the two ends of the letter to those of its inverted image in the retina, and the greater is the acuteness of vision if this image can still be perceived distinctly. Therefore, by determining the smallest angle under which an object can still be recognized by the eye, we determine the degree of acuteness of vision. This angle is termed *the angle of vision*, or *the visual angle.* Some persons see objects under a smaller angle, and therefore possess a greater acuteness of vision. But people in general, to see an object distinctly, must see it under an angle of 5°. It is not necessary to measure this angle, as long as we possess a series of objects, the sizes of which are known, and have ascertained by experiment the farthest distances at which such known objects are still recognized by the normal eye.

For practical purposes (as objects with which to ascertain the acuteness of vision) "*test types*," or series of letters of different determined sizes, have been introduced; those of Dr Snellen of Utrecht (Holland) are the most perfect.

An explanation of the principles adopted when selecting and arranging the letters, and of the conclusions which may be drawn from the results of examination with the "test types," is given by Dr Snellen, together with the types.

Those who may not be able to obtain the "test types" may use any other type, as long as the thickness of the strokes of the letters employed is equal to one-fifth of their height. The height of the letters should be the same for each series, but should vary according to the distances at which they are held from the eye. Experiment has shown that the farthest distance from the eye at which a letter, measuring about one-fiftieth of an inch ($=\frac{1}{50}''$) in height, can be recognized distinctly by a normal eye, is one foot ($=1'$). When measuring about $\frac{2}{5}''$ the farthest distance at which it can be recognized is $2'$, when measuring about $\frac{5}{50}''$ or $\frac{1}{10}''$, it is $5'$; when measuring about $\frac{10}{50}''$ or $\frac{1}{5}''$, it is $10'$; for letters $\frac{20}{50}''$ in height, $20'$; for those of $\frac{100}{50}''$, it is $100'$, &c., provided always that the thickness of the stroke of each letter be one-fifth of its height. We may thus arrange a series of letters,

and number each series. The letters of the series No. 1, or of series I., should measure each $\frac{1}{50}''$ in height, and should be recognized at 1′, and not farther Those marked II., or No. 2, should be recognized at 2′; those marked XX., or No. 20, at 20′, &c., &c. The number above each series indicates the distance in feet at which the eye under examination, if healthy, should recognize each letter of the series; and the acuteness of vision is normal (V or S = 1) if I. can be recognized at 1′; II. at 2′; XX. at 20′; C. at 100′.

By this method the degree of acuteness of vision may be expressed by a fraction, of which the number above the horizontal line represents the distance at which the test letters can be recognized by the eye under examination, and the number below the horizontal line the distance at which the test letters can be recognized by the normal eye: e. g. $V = \frac{1}{I}$, or $V = 1$, signifies that at 1 ft letters of No. 1 (i. e. those which at 1 ft should be recognized by a normal eye) can be recognized by the eye under examination, and that therefore that eye is normal as far as acuteness of vision for objects placed at 1 ft from the eye goes. Instead of writing $V = \frac{1}{I}$, we may then write $V = 1$. $V = \frac{20}{XX}$ signifies that at 20 ft letters of XX. (i. e. those which at 20 ft should be recognized by a normal eye) can be recognized by the eye under examination, and that therefore the eye is normal, as far as acuteness of vision for objects placed at 20 ft from the eye goes. Instead of writing $V = \frac{20}{XX}$, we may write V for distance = 1. If letters which should be recognized at 20 ft can only be recognized at 10 ft, we write $V = \frac{10}{XX}$, or $\frac{10}{20}$, or $V = \frac{1}{2}$; if they can only be recognized at 5 ft, we write $V = \frac{5}{XX}$, or $\frac{5}{20}$, or $V = \frac{1}{4}$, &c., &c. The number above the horizontal line always expresses the distance at which the test letters can be recognized by the eye under examination, and the number below the horizontal line the distance at which the test letters can be recognized by the normal eye, or ought to be recognized by the eye under examination if normal.

The acuteness of vision is somewhat influenced by the size of the pupil. The acuteness of vision is increased in weak light when the pupil is dilated, and in strong or diffused light when it is contracted. We should, therefore, pay attention to the degree of light employed in the examination.

The range of accommodation and the acuteness of vision diminish as age advances.—The former is shown by the necessity of holding small objects farther from the eye in order to see them distinctly, the latter by the eye being no longer able to distinguish objects of certain sizes at the same distance at which they could be recognized in youth.

The images formed in and perceived by the retina and the functions of the optic nerve fibres become less perfect. Up to the age of forty vision remains about normal. At the age of sixty it has already much decreased, so that, for instance, letters of No. 20 can only be recognized at from 15′ to

18′. At the age of eighty the acuteness of vision is about half as good as it was at forty.

The Field of Vision (=*F*).

We distinguish belween dircct and indirect vision. In direct vision the object perceived lies opposite the yellow spot of the retina, one or both the visual lines being directed to the same point of the object. In indirect vision objects are perceived which lie opposite other parts of the retina. In indirect vision the images of objects are formed in the more excentric parts of the retina. The place occupied by the image in the retina determines the part of the field of vision upon which the image is projected. Any objects perceived indirectly, while one or both visual lines are directed to one point of some other object, lie in the field of vision. Having determined V, or the acuteness of direct vision, we proceed to ascertain F, or the field of vision.

The limits or boundaries of the field of vision are given by the most excentrically placed points of objects, which can still be perceived while one or both visual lines remain directed to some particular object.

We must distinguish between the field of vision and the field of fixation; the latter comprises those points in the field of vision which, without altering the position of the head or body, can still be seen directly.

The field of vision of one eye, and that of both eyes together, have been measured. That of one eye is sharply divided into lateral halves, a temporal and a nasal half (see Hemiopia). A line drawn through the points which limit the field of vision forms an ellipse. Vertically the field measures about 160°; horizontally about 170°. Great prominence of the margin of the orbit or of the bridge of the nose limits the boundaries of the field.

The percipient elements of the retina decrease in a certain proportion from the centre (or yellow spot) towards the periphery, and more rapidly in the vertical than in the horizontal direction. Having ascertained the extent or boundaries of the field of vision, we may wish to determine the acuteness of the retina as regards the perception of objects situated in different parts of the field.

Modes of ascertaining the extent of the sensitive part of a retina, or the field of vision of one eye.—A record of the extent of the sensitive portion of the retina, to enable us to compare the course of retinal and other changes, the effect of treatment, &c., may be kept in the following manner:—A sheet of dull dark blue paper (size two feet square), with a small white cross traced in the centre, and a vertical and a horizontal line intersecting each other at the centre of the cross, and dividing the paper into quarters, is fixed upon a wall. The patient stands at the distance of 12 in. from the paper, facing the white cross, which should be on a level with the eye under examination, while the other eye is kept closed.

The patient is directed to look steadily and continually at the cross while we move a piece of white chalk, fixed on a black handle, from the margin of the paper towards the cross. A mark is made at the spot at which the white chalk first becomes visible. Repeating this movement from different parts of the margin of the paper towards the cross (and not from the latter towards the margin), we obtain a series of points which correspond to the most peripheral sensitive portions of the retina. Through these we draw a line, and the figure thus obtained represents the extent of the sensitive portion of retina, or, in other words, the limits of the field of vision of the eye under examination. This record, if taken from an impaired retina, should be compared with tracings of the limits of the field of vision of the retina of a corresponding healthy eye.

The field of vision thus obtained is termed *the quantitative field of vision,* while the so-called *qualitative field of vision* refers to the perception of letters at varying distances from the white cross. The limits of both kinds can be marked on the same sheet of paper; and, measuring horizontally and vertically from the cross, we state that the quantitative and qualitative perception horizontally outwards and inwards, and vertically upwards and downwards, amounts to so many inches, &c.

A useful and quicker mode of ascertaining the sensibility of the more excentric parts of the retina, and with it the limits of the field of vision, is the following:—Suppose we wish to examine the excentric parts of the retina of a patient's right eye; we place ourselves at a distance of two feet facing the patient. We then direct the patient to look steadily at our left eye, which, during the examination, is continually directed towards the patient's right eye. If, by moving our hand at equal distances from our own and the patient's eye, and opposite the excentric parts of the retinæ of both, we find that the patient perceives these movements at the same distances as we do with our healthy retina, we suppose the peripheral portions of the patient's retina to be sensitive.

Each part of the field of vision refers to a portion of retina opposite that part; suppose e. g. that, moving the hand in the outer and upper quarter of the field, its movements are not perceived by the patient, we infer that an alteration of sensibility of the inner and lower quadrant of the retina exists.

Whatever modes of ascertaining the sensibility of excentric parts of the retina be adopted, care should be taken that the position of the patient's eye and its distance from our own eye remain unaltered during the examination, and that they are the same whenever the examination is repeated.

The sizes, forms, and distances of objects.

In the formation of ideas of the sizes, forms, and distances of objects,

we are guided by the sizes, &c., of the images of these objects in the retina, and by the degree of power of accommodation required to produce distinct images. For the same purpose we make use of certain movements of the eyes, of the head, and of the body.

If we have a knowledge of the exact sizes, forms, and distances of a few objects, we possess a guide in forming our judgment of the sizes, &c., of others. Thus, by a continuous repetition or modification of the muscular efforts, which are necessary to see in succession different objects and their details, we acquire experience as regards the muscular power which each time is required to recognize the size, &c., of any particular object, and to this experience we appeal when examining new objects. The size of the image of any object on the retina varies with the distance of the object; and knowing the sizes of some objects and those of their retinal images, we possess a second means by which we improve our ideas as to the sizes, distances, &c., of other objects.

If the length or size of an image formed on the retina by an object be required: then having given the length of the object, equal to any assumed length (e. g. 3 feet), and the distance of its middle point, measured along a line, which we assume to be a continuation of the optic axis from the nodal point, equal to 7 feet, we have AB (the length of the object) : ab (the length of its image in the retina) : : NE (the distance of the middle point of the object from the nodal point) : Ne (the distance of the middle point of the image in the retina from the nodal point) AB : ab : : NE : Ne, hence ab $= \frac{AB}{NE} + Ne$.

Now, Ne expresses the distance of the image on the retina from the nodal point, and this distance is constant. The distance NE varies, but the distance Ne remains invariable, and is equal to $\frac{5}{8}$ of an inch. The length of the image, expressed in fractional or decimal parts of an inch, is found by multiplying $\frac{5}{8}$ by the fraction $\frac{AB}{NE}$.

In the case assumed, AB = 3 feet, and NE = 7 feet. Hence the length of image $= \frac{3}{7} \times \frac{5}{8}$ inch $= \frac{15}{56}$ or ·26785 inch. It is necessary that AB and NE be expressed in, or be reduced to the same denomination. Thus, if it be required to find the size or length of an image formed by an object 10 inches in length, and placed at the distance of 8 feet from the nodal point; then length or size of image $= \frac{10}{8 \times 12} \times \frac{5}{8}$ inch $= \frac{25}{384}$ or ·0651 inch.

The idea of bodily form of any object is chiefly developed by the dissimilarity of the retinal images of the two eyes. While looking at one point of an object this point appears single, and all others appear double. By then viewing in succession other points of the same object, we each time alter the convergence of the eyes as well as the sizes of the two retinal images, and with these the distances of those points of an object which are

seen double. We thus gradually acquire an idea of what is termed the form or solidity of an object.

We must more particularly allude to the mode in which an idea of the size of an object is developed. Suppose we distinctly see a line of unknown length at a known distance, and are required to state what the length of the line amounts to. To do this we direct the visual line first to one end of the line, then along the line to the other end. The visual line has thus to describe a certain angle, or to travel over a certain distance, and upon the estimation of this angle or this distance (that is, upon the amount of muscular power required to describe the angle) depends our statement as regards the length of the line; e. g. if we look from one end of a line, which is one foot long, to the other end, our visual lines have to travel a shorter distance than when looking in the same way at a line which is five or ten feet long, or more. Less muscular power is required to look over the first than over the second line; and it is from the experience acquired by repeating the experiment unconsciously upon objects which surround us that we finally possess the power of rapidly stating the size of any object—its height by estimating the distance of its two extreme points from each other in a vertical direction, its width by estimating the two extreme points in a horizontal direction.

Our estimation of the rate of motion of an object depends upon the muscular power which is required to maintain a distinct view of the object in motion. The sensation of the movement of our muscles gives rise to the idea of motion. To form an idea of the rate at which other objects move, we must either be at rest or we must know our own rate of motion.

Perception of colours, and its anomalies.

Colours, to be recognized as such, must occupy a certain amount of surface, and be illuminated by a certain quantity of light. These conditions vary with different colours, e. g. a red square figure of a certain size, and on a white ground, if badly illuminated or very small, may still be recognized as regards its square shape, but no longer as regards its colour, which appears black. A blue square figure appears black at a shorter distance from the eyes than a red one.

The power of distinguishing colours is greatest in the region of the yellow spot; and decreases towards the periphery of the retina, though not with equal rapidity in all directions. A square figure of any colour, painted on white background, when carried slowly from opposite the yellow spot to opposite the more peripheral parts of the retina, gradually becomes indistinct, and finally black. It at first appears smaller, and becomes at last ill-defined. The colour of the figure becomes indistinct sooner than its

shape. A yellow, green, blue, or red square on a black background gradually becomes white.

The larger the coloured surface the farther from the yellow spot can its colour be recognized. No exact relation exists, however, between the rapidity with which the power of recognizing a colour decreases, and the size of the coloured surface. The power of recognizing colour is limited by the time during which it is exposed to view, and this varies for different colours. Any colour, when looked at for a certain time, gradually fades.

We distinguish, as regards *anomalies in the perception of colours*, those cases in which, in the course of a gradually increasing amblyopia, the perception of tints, and finally that of pure colours, is lost; and those in which vision, as regards acuteness, is not at all or but slightly impaired. To the latter group the term *Daltonism*, or colour blindness, is applied. There may be complete loss of perception of colours, or only loss of perception of some colours. Complete colour blindness (achromatopsia), in which condition only black and white can be recognized, is rare. Generally the defect is confined to a few colours; while varieties in the intensity of those colours which can be recognized are often more rapidly perceived than by a healthy eye. Red or yellow are distinguished with difficulty, or not at all, from grey, blue, and other colours. Frequently red and orange cannot be recognized, rarely green. Some eyes can only distinguish tints of yellow or blue; a few can only distinguish yellow.

In the slightest degrees much light is required to recognize the colour for which the sensibility is diminished. Daltonism is congenital, and is observed in children from parents of blood relationship; it is frequently hereditary; it is incurable, and continues for life.

Chromato-dysopia, or the mistaking of colours, which in the solar spectrum are very distant from each other. Most frequently colours which are related to each other, or shades of the same colour, particularly violet and lilac, are mistaken.

Coloured vision (*Chromopsia, or Chrupsia*).

Persons suffering from this affection complain that all objects appear of one colour (yellow, green, red, &c.). Coloured vision may be intermittent, or may change from one colour to another. It occurs in the course of cerebral disease, after undue exertion of the eyes, and after operations for cataract. To persons who have taken a large dose of santonin grey objects appear greenish-yellow. Pure white santonin, if exposed to light, as in the media of the eye, turns yellow. In some cases benefit has been derived from prescribing spectacles with glasses of the colour complimentary to the one under which objects appear to the patient. Cases of coloured vision have occurred in which, in a word, or in a series of figures, different letters or figures have appeared of different colours.

Photopsia (*Spintherismus, Phosphenes, flashes of light*).

Photopsia is observed in blind as well as in seeing persons. "Fiery wheels," "balls," "stars of yellow, green, and red colours," "flashes of lightning," "rain of fiery sparks," "a mass of fire floating in the eye," "shining clouds moving about in the eye," "an appearance as if the eye were lighted up with moonlight," and similar photopsiæ, are observed during sudden movements of the eyes; after blows on the eyes; after undue exertion, especially in bright light; during inflammatory changes affecting the relations of the rods and bulbs to the adjoining parts; during extra-ocular changes, causing hyperæmia of the optic nerve-fibres; after poisoning by gases, by alcohol, &c.

To test the power of the retina for perception of light we use artificial light. A record of the degree of this power becomes necessary if the patient has only perception of shadows, or can merely distinguish light from dark, as in advanced cataract or in amblyopia.

The patient being placed as for ophthalmoscopic examination, we throw light with the ophthalmoscope upon the different parts of the sclerotic, iris, and pupil, and vary the quantity of reflected light, by decreasing the intensity of the flame, or by holding the instrument farther from the eye. The experience obtained from the comparison of different eyes (with or without cataract, but with healthy retinæ), examined in this way, teaches us the quantity of light which should be perceived by a healthy retina. For example, if light cannot be perceived, when thrown from above upon the upper half of the sclerotic, so as to reach the lower half of the retina, while the direction from whence the light comes is readily recognized when it is thrown on other parts of the sclerotic, we may rest satisfied that the lower half of the retina does not perceive light.

Duration (*persistence*) *of Retinal impressions.*

Many of us must have observed that, after looking for a short time at the red disc of the setting sun, the disc often remains visible for a minute or longer, though the eyelids be closed. The retinal impression has remained persistent beyond the usual time. One-eighth of a second is the average time during which a retinal impression at the yellow spot persists before another one can take its place. The time of persistence can, by practice (by looking at a clear line on a dark background for a certain time), be increased to half-a-minute. At the yellow spot a more persistent retinal impression fades away gradually in some, with intermission in others, while in the more peripheral parts of the retina it always disappears by intermissions, i. e. it disappears, then suddenly reappears somewhat fainter, and so on.

In some morbid changes of the visual apparatus the persistence of retinal impressions has been known to continue for days and weeks, and to return whenever the patient's thoughts have reverted to the objects of the impressions.

Binocular Vision.

By binocular vision, i. e. by vision with both eyes at the same time, we obtain: (1.) A larger field of vision. The inner (nasal) half of one retina perceives objects which are not seen simultaneously by the inner half of the fellow retina. (2.) A better idea of the bodily forms of objects (each eye viewing the same object from different sides); and of the rate of motion, especially of those objects which recede from, or approach the eyes.

A difference in the shape, and with it a difference in the refraction of the two eyes, if exceeding certain limits, disturbs binocular vision; and that eye is used with which at the required distance vision is most acute. For superficial observation of objects, especially if the power of converging the eyes is well developed, binocular vision may exist, even with great differences in refraction. Protrusion of one eye, or differences in size between the two eyes within certain limits, may cause an object, placed at the same distance from both eyes, to appear smaller to one, i. e. to the less prominent eye, because the crossing point of the rays in this eye lies nearer the retina; and to appear larger to the other, i. e. to the more prominent eye, through the crossing point being situated farther from the retina. With both eyes open the object appears of a size which is the medium between that which it would appear to one eye, and that which it would appear to the other. Binocular vision is lost, in consequence of changes which impair vision of one eye only, and also through strabismus.

The existence of binocular vision is established by alternately covering each eye during reading, when the uncovered eye should continue to read; or by placing a prism before one eye with the refracting angle upwards, when diplopia should appear, the double image, possessing the same distinctness as the true one. If binocular vision is absent we should examine the defective eye, and by practice we should increase its acuteness of vision.

Combined vision, though no longer binocular, exists, if the two eyes assist each other, e. g. in judging of the shape, distance, &c., of an object, as is the case if a cataract has been removed from one eye. Though there be differences in the distinctness and sizes of the images formed in each retina, yet the field of vision remains undisturbed, and the functions of both retinæ are maintained in greater perfection. In myopics, operated upon for cataract in one eye, it occasionally happens that the eye operated upon is used for viewing distant objects, and the other for reading.

Vision with one eye.—The sensation of muscular action experienced during accommodation, and during convergence, especially if the other eye

is not destroyed, is the only means by which one eye can judge of the sizes, distances, and shapes of objects. Assistance is afforded in this by the movements of the head and body.

ANOMALIES OF VISION.

The anomalies of vision (independently of those arising from disturbances of the "appendages of the eyeball," the eyelids, the lachrymal apparatus, and the conjunctiva) are subdivided into those which are the results of anomalies—(1.) Of the refracting surfaces; (2.) Of the transparent media; (3.) Of the parts concerned in accommodation; (4.) Of the retina; (5.) Of the optic nerve or brain.

A short recapitulation of the numerous terms which are made use of by patients to designate the different kinds of impaired vision is necessary, together with an explanation of such terms.

(*a.*) Lesions of the power of recognizing the positions, distances, sizes, forms, and rates of motion of objects.

1. "*The patient with both eyes open sees double.*" *This is Diplopia.*

Diplopia (*double vision*).

An object, e. g. a luminous point, appears single if both visual lines are directed to the point. The point appears double if we look at an object placed in a straight line beyond it, while this object in its turn appears double if we look again at the point.

This form of diplopia occurs continually in healthy eyes, it is necessary for the development of the idea of bodily form, and does not disturb vision.

Another form of diplopia may arise from great differences between the two eyes, in accommodation or refraction or shape. Each difference causes the images of objects in one retina to differ so much in size from those in the fellow retina that they can no longer be combined, but appear to the one eye larger, and to the other smaller.

Here we treat of the diplopia which appears if one of the visual lines (one eye) is directed to the point we wish to look at, while the other visual line (the other eye) is directed elsewhere.

The double image appears in a direction opposite to the one in which the visual line deviates. For example, suppose the left eye to see double, its visual line deviating inwards ("the eye squinting inwards") while the right is directed to a point straight in front; the image of the latter point is formed in the yellow spot of the retina of the right eye, while in the left

eye it is not formed in the yellow spot but in a portion of the retina which lies more internally. This image is termed *the double image, or pseudo image,* to distinguish it from *the true image,* i. e. from the one to which the visual line is directed.

A double image must necessarily be formed if one eye squints. The double image is frequently not perceived in consequence of the patient giving all attention to the ("true") image formed in the properly directed eye. The double (generally less distinct) image occupies a more peripheral (less sensitive) part of the retina, or one which is morbidly altered.

We often succeed in proving to such patients the existence of diplopia by placing a dark violet glass before the normally directed eye. This weakens the distinctness of the true image and colours it. Or we may displace the double image with a prism towards a more sensitive part of the retina.

The diplopia is the more troublesome the nearer the images are to each other.

The double image is termed *homonymous* or *homolateral* if, belonging to the right eye, it lies on the right side of the true image; or belonging to the left, it lies on the left side of the true image. It is termed *intersected,* or *crossed,* if the double image belonging to the right eye lies to the left of the true image, or towards the patient's left side; and if the double image belonging to the left eye lies to the right of the true image, or towards the patient's right side.

The double image may stand higher or lower than the true one. It is termed "*inclined,*" "oblique," or "slanting," if instead of being parallel with the true image, it is more or less inclined towards, or away from it. It is inclined outwards if its upper extremity recedes from the median line, &c., &c.

The position of the double image varies according to the muscle or muscles which are impaired, and its distance from the true image is proportionate to the degree (angle) of deviation of the visual line.

It may be desirable to express numerically the difference in height, the lateral distance, and the inclination of the double image, and with it the inclination of the horizontal and vertical meridians of the cornea. To do this we place the patient, with the head fixed, facing a black board. The latter stands parallel with the patient's face, about five feet from it, and is divided into squares, which are numbered. The flame of a candle is then moved in horizontal, vertical, and oblique directions from the median line, and the two images of the flame, the one of the properly directed and the one of the deviating eye, are perceived opposite different squares of the board. We likewise ascertain the point where the diplopia commences, and also whether the position and inclination of the double image is influenced by certain directions of the eyes being maintained for some time.

From the distance of the square, opposite which the true image is perceived, from the one opposite which the double image is seen, we can (making allowance for the distance of the eye from the board) form an idea of the distance of the double image from the yellow spot; and with it of the extent of the deviation of the visual line, and also of the muscles which contribute towards the diplopia.

Instead of the black board and flame a prism may be used to express the amount of displacement of the double image. We state the degree and the position of the refracting angle of the prism, which is required to unite or bring near each other the images. For example, suppose the left eye to diverge outwards and slightly upwards, and the distance between the true and the double image to amount to 4 inches, while both eyes look at the flame of a candle placed at the distance of 3 feet from the eyes. In such a case we try several prisms, and by placing one of 12° before the diverging left eye, holding it in the proper direction, we suppose that we obtain single vision. We then state that the degree of diplopia at that distance is equal to a prism of 12°, and we also state the direction of the refracting angle.

2. "*The patient sees double, treble, &c., with one eye alone.*" (See Polypia.)

3. "*Objects seen with one eye or with both appear too small*" (this is termed *Mikropia*, and is frequently observed during anomalies of accommodation, or sudden changes in the position of the crystalline lens).

4. "*Objects seen with one or both eyes appear too large*" (this condition is termed *Megalopia*). The causes are similar to those just stated, but act in an opposite direction.

5. "*An object can only be recognized by rolling the eye about, or by holding the object sideways.*" Corneal opacities and lesions of the yellow spot have been observed among other causes.

6. "*Objects appear distorted, bent,*" *&c.* (=*Metamorphopsia*). Anomalies of the light-refracting parts and lesions of the retina or brain may be the causes.

7. "*Only half or part of an object can be seen.*" (See Hemiopia and Scotoma.)

8. "*Objects which are at rest appear in motion.*" (See Paralysis and Paresis.)

9. "*The distance of an object is judged wrongly, or cannot be determined at all.*" The usual causes are, sudden loss of one eye; the use of spectacles, for going about with, by persons advanced in age, who have not worn any before; the use of spectacles by those who have been operated upon for cataract; paresis and paralysis of the muscles which come into play during accommodation.

10. "*An object has to be looked at some time before it can be recognized*"

(=*slow vision*). This symptom is connected with lesions of the ciliary muscle, retina, optic nerve, or brain.

11. "*Objects appear standing before the eyes for some time after the eyes have been closed,*" (=*Persistent vision.* See Duration of Retinal Impressions).

12. "*The images of objects, just perceived, vanish and return, the eyes being kept closed*" (=*Intermittent vision.* See Duration of Retinal Impressions).

13. "*Objects, especially small ones, after having been looked at for some time, become misty. On closing the eyes for a moment, or rubbing them, the objects can again be seen distinctly for a short time*" (=*Weak sight, Impaired vision,* &c. See Asthenopia and Circles of Diffusion).

Circles of diffusion (*Circles of diffused light*).—To form an idea of circles of diffusion, and of their effects upon vision, we should produce them artificially. To do this we may trace two parallel vertical lines on white paper. We then close one eye and look with the fellow eye through a concave lens of 5-inch focus at the lines held at the distance of 4 inches from the eye. We at once observe that the contours of the lines become ill-defined and appear coloured.

The ill-defined coloured margins (when the lines are held at a distance of 10 inches from the eye) appear much larger, and merge into each other, occupying the space between the lines, so that the latter cannot be recognized, or only with difficulty.

The cause of the circles of diffusion is found in the retina not being situated exactly at the focal distance of the dioptric system of the eye (whether this be the result of anomalous shape of the eyeball or of derangements of accommodation). Each point of an object, instead of being seen as a point, appears as a diffused spot, hence the diffused appearance of the margins of objects.

The margins of the circles of diffusion run parallel with the lines, and, looking at letters, we observe that their strokes can be recognized even from the arrangement of the circles, though the strokes themselves appear very indistinct. Persons operated upon for cataract, and those whose refraction is disturbed, thus guess at the shapes of letters, objects, &c. Screwing up the eyelids, or contracting the pupil, or looking through a small opening, very much reduces the disturbing influence of these circles, as long as the circles of one stroke do not merge into those of the adjoining one. Reading becomes impossible when once the circles of diffusion of the strokes of each letter merge into each other.

(*b.*) Lesions of the power of recognizing colour.

The patient states—

1. "*That all objects appear of the same colour*" (=*Coloured vision. Chro-*

mopsia). This symptom is observed occasionally in persons who have been operated upon for cataract and in those suffering from changes in colour of the transparent media, as may occur, e. g. during jaundice.

2. "*That objects, as the flame of a candle, &c., seem surrounded by rainbow colours.*" (See Glaucoma, Conjunctiva, and Cornea.)

3. "*That colours cannot be perceived at all, or that only some can be recognized, or that colours are mistaken*" (=*Colour blindness.* See Perception of Colours).

(*c*.) LESIONS AS REGARDS SENSIBILITY TO LIGHT.

The patient states—

1. "*That light dazzles the eyes.*" (See Photophobia, or Intolerance of Light.) The usual causes of this condition are corneal opacities and other superficial changes of the cornea. It is also observed during hyperæmia of the optic nerve, as in many cases of Myopia, and in Glaucoma.

2. "*That much time is required before he can see when coming from a light into a dark room.*" (See Night Blindness.)

3. "*That the ordinary amount of light is no longer sufficient to see small objects.*" (See Presbyopia.) The functions of the retina and brain should be examined.

4. "*That on closing the eyes, or in the dark, flashes of light, fiery circles, falling stars,*" &c., *are seen* (= *Photopsia, Phosphenes.* See Myopia and Morbid Changes of the Optic Nerve and Retina).

The diagnosis and treatment of anomalies of vision are most facilitated by ascertaining in succession in every case the functions of the parts necessary for vision. These are—

1. The light refracting portions of the eye (comprising the cornea, the aqueous humour, the crystalline lens, the vitreous substance) together with the retina (the screen upon which inverted images of objects are to be formed), as far as regards its curvature and its distance from the nodal point. Anomalies in the curvature of one or of several of these structures disturb the refraction of light, and thus give rise to impairment of vision. To this group of anomalies belong myopia, hypermetropia, and astigmatism.

2. The media of the eye (i. e. the parts which in health are transparent when viewed with the unaided eye), excepting the retina and the optic disc. The kinds of disturbances of vision caused by impaired transparency of the media are described under Opacities of the Cornea, Closed Pupil, Cataract, Opacities of the Vitreous Substance. The light, instead of reaching the retina in the usual way, is diffused over it, and objects appear misty, and the contrast between light and shade is diminished.

3. The parts concerned directly, or indirectly in the accommodation of

the eye. These are the crystalline lens, the ciliary muscle, the parts immediately adjoining these, and the external muscles of the eye. The number of persons whose vision is disturbed by anomalies in these parts is very great. The anomalies of refraction often make themselves felt by disturbances of the accommodation. Most cases of what by some is termed painful vision belong to this group. Senile changes affecting the contractility of the iris and ciliary muscle, and the elasticity and consistency of the crystalline lens, are fertile sources of derangements of vision. (See Presbyopia, Cataract, Anomalies of Accommodation, Insufficiency of the recti muscles.)

4. The retina, optic disc, and the tunics adjoining them.

5. The optic nerve, the brain, and those other parts of the nervous system which are essential to vision.

The impairment of vision, when caused by lesions of the parts mentioned under 4 and 5 (whether the lesion has originated in the part, or the latter has become impaired secondarily), is termed *Amblyopia* (ἀμβλὺς = obtuse, and ὤψ = eye) *as long as there is perception of light, Amaurosis* (ἀμαυρος = blind) *if vision is entirely destroyed.*

Previously to ascertaining the state of the parts just mentioned, we must not neglect examining the appendages of the eyeball, the eyelids, the conjunctiva, the lachrymal apparatus. Slightly perceptible changes of these parts may give rise to disturbances of vision which may much distress the patient; e. g. the mucus of slight catarrhal ophthalmia may give rise to muscæ, or to chromopsia.

Impairment or destruction of the functions of certain portions of the retinæ or of the optic nerve fibres often lead to forms of amblyopia or amaurosis, which in themselves are characteristic of the morbid changes of which they are symptoms.

The following are the more frequent kinds of amaurosis or amblyopia—

Amblyopia or amaurosis of circumscribed portions of the retina.

A circumscribed amblyopic or amaurotic portion of the retina is termed *a "scotoma."* The scotoma gives rise to interruption of the field of vision.

(1.) *Scotoma in the region of the yellow spot* (*central scotoma, central interruption of the field of vision, impairment of direct vision*).

Scotoma in the region of the yellow spot may appear after looking into strong light, or after working too much at the microscope. It may appear in both eyes if both are used in succession. In the eye thus used a yellowish mist is noticed. This mist is followed by a deep brown one if the work which caused it be continued. Objects placed opposite the region of the yellow spot can no longer be perceived. Hours may elapse before the mist has cleared away, and vision has become normal again.

The boundary of the impaired portion of retina is ill-defined, while the

function of the more peripheral parts may continue undisturbed. With the ophthalmoscope we observe an increased greyish haze surrounding the reddish centre of the yellow spot.

From this kind of scotoma, which may recur whenever cause is given, we distinguish the one which appears more gradually without any apparent cause often in both eyes, and which remains.

On ophthalmoscopic examination in the latter case we may find choroido-retinitis and loss of transparency, followed by local pigmentation and atrophy.

Peripheral parts of the retina sometimes acquire in such cases a degree of acuteness which is not possessed by equally excentric parts of the healthy retina.

Another form of central scotoma is that caused by cerebral or extra-ocular changes. In these changes the ophthalmoscopic examination is often negative, and the boundaries of the impaired portions of retina are very irregular. The arrest of the function of a certain number of optic nerve fibres, e. g. from cerebral changes, gives rise to impairment of the function of those parts of the retina to which such fibres belong. A scotoma is observed opposite the impaired part of the retina, while the rest of the retina remains normal. The functions of the more excentric parts of the retina are likewise annihilated, if the elements of the retina and the entire layer of optic nerve fibres are destroyed.

The following mode of ascertaining the extent of small central scotomata (the fellow-eye being healthy), has been proposed :—

The patient is directed to look at a white spot on black dull paper. To healthy eyes the white spot, viewed through a blue-tinted glass held before one, and through a yellow-tinted glass held before the fellow eye, appears of a dirty green colour. If the region of the yellow spot, e. g. of the left eye, is impaired (the healthy right eye looking through the yellow, and the left through the blue-tinted glass, at a piece of white chalk held at the side of the white spot), then the spot and the piece of chalk appear yellow. The chalk appears of a dirty green colour (on moving it along the black paper, away from the white spot, both eyes being fixed on the latter), the moment a point is reached where both retinæ participate in the act of vision. The shape of the impaired portion of retina can be found by ascertaining a certain number of such points.

(2.) *An amblyopic or amaurotic portion, i. e. a scotoma, adjoining the optic disc, and most frequently the portion next the yellow spot. "Enlargement of the blind spot."*

Small blind or impaired portions of the retina adjoining the optic disc are generally not noticed by the patient. Large ones, if encroaching upon the region of the yellow spot, betray themselves by portions of an object,

situated externally to the point directly looked at, appearing indistinct or missing. The impaired portion is rarely irregular; generally it is transversely oval. Atrophic changes, commencing at the choroido-retinal aperture, and following inflammation, or simple distension as in extreme myopia, are the usual cause.

These changes when recent, and appearing rapidly, for a time impair ("dazzle") the vision of the fellow eye.

To make the impaired portions of retina more strikingly perceptible, we cause the patient to look, with the affected eye, through a small opening at a strongly illuminated white surface: the impaired portions appear as dark spots.

(3.) *Amblyopia or amaurosis of other parts of the retina; excentric scotomata; Excentric interruptions of the field of vision.*

If excentric portions of the retina are not destroyed, but only impaired, we find the patients complain of differently-shaped grey, black, or coloured spots. These either obscure portions of an object, or cause them to appear indistinct, misty, or distorted, or too small or too large. Small impaired spots are often overlooked, especially if confined to one eye, and are best perceived if the other eye is closed. They are generally the result of choroido-retinitis.

(4.) *Amblyopia or amaurosis, progressing from the periphery (margin) of the retina towards the yellow spot; Contraction or Limitation of the field of vision.*

The impairment of vision,

1. May be confined to one-half of the retina ("hemiopic limitation").

2. May advance to an equal extent from all points of the periphery of the retina towards the yellow spot ("concentric limitation"), as frequently occurs in both eyes of the same patient. A zone of amblyopic retina generally joins the amaurotic one.

3. May advance more rapidly from one side ("irregular limitation").

Of this latter different varieties occur, e. g. the amblyopia or amaurosis may progress more rapidly from the outer margin of the retina, as in cupping of the optic disc; or more rapidly from above and below, as in anæmia and atrophy of the optic disc; or irregularly from all sides, as in the different forms of choroido-retinitis.

The "amaurotic" portions of the retina may join healthy portions; but more frequently they are contiguous with "amblyopic" ones.

Cerebral changes, affecting vision, lead simultaneously to excentric limitation and to impairment of direct vision, but not to morbid changes in the retina.

If, from impeded innervation or from non-use, direct vision is much

impaired while the excentric parts of the retina remain sensitive throughout, the prognosis is better than if direct vision is good, but the excentric parts are much or irregularly impaired.

(5.) Hemiopia; half-vision.

The right halves of the two retinæ (the outer or temporal half of the right, and the inner or nasal half of the left retina) are supplied by the right optic nerve tract, and the left halves of the two retinæ (the outer half of the left and the inner half of the right retina) are supplied by the left optic nerve tract. The right and left optic nerve tracts meet at the chiasma. The fibres of the outer half of each tract go, those of the right tract to the optic nerve of the right eye, and thence to the outer half of the retina of the right eye, those of the left tract to the optic nerve of the left eye, and thence to the outer half of the retina of the left eye. The fibres of the inner half of each tract cross each other at the chiasma, those of the right tract crossing over to become the inner half of the left optic nerve, and to go to the inner half of the left retina, those of the left tract to become the inner half of the right optic nerve, and to go to the inner half of the right retina. Non-crossing of the tracts of the optic nerves, or absence of the chiasma, with and without impairment of vision, have been observed by several anatomists. There also occur in the chiasma fibres which go from retina to retina, and others which pass from one side of the brain to the other.

The varieties of hemiopia are, in order of frequency—

1. Loss of vision of the outer half of the right, and of the inner half of the left retina from paralysis of the right optic nerve tract; and loss of vision of the outer half of the left, and of the inner half of the right retina from paralysis of the left optic nerve tract. The line of demarcation between the sensitive and blind part of the retina is vertical and sharply defined. On examination with the ophthalmoscope we find both optic discs healthy or hyperæmic, but never any morbid change confined to one-half only of either disc. The two forms of hemiopia are observed in the course of tumours, of apoplexy with hemiplegia, of diabetes, &c. The morbid changes which cause the hemiopia are situated on one side of the brain. We infer, if loss of vision of the entire retina follows, that these changes are no longer confined to one side of the brain. Hemiopia after apoplexy remains stationary in many cases, and blindness need not necessarily follow.

Tumours and periostitis at or near the chiasma may give rise to any of the above, or to the subsequently mentioned forms of hemiopia. The hemiopia caused by changes about the chiasma is often followed by loss of vision. In some cases the functions of one optic nerve are restored, and the hemiopia remains stationary for years.

2. Loss of vision of the outer half of each retina (of the right half of the right, and of the left half of the left retina). This form, as regards vision, is the least troublesome.

3. A very rare form is paralysis of the inner half of each retina. It has been observed in the course of intra-cranial tumours.

(6.) Night Blindness (Hemeralopia).

This anomaly of vision is characterized by sudden impairment of vision, amounting in rare cases to loss of vision, as soon as the quantity of light decreases beyond a certain point. Hemeralopic persons often enjoy "normal" or "nearly normal" vision in full daylight.

Night blindness varies in degree, and frequently in the two eyes of the same person.

The dilated and sluggish pupil, and the want of power of the ciliary muscle, with insufficiency of the internal recti muscles, observed in many cases, seem not to be owing to paresis of the third nerve, since the application of tincture of opium to the conjunctiva causes active contraction of these parts. In rare instances only the region of the yellow spot is affected; "a dark brown cloud" obscures objects which, when held opposite lateral parts of the retina, are distinctly recognized. Red, blue, or violet light is not perceived so readily as green, yellow, or white light. Night blindness, if it appears suddenly after exposure of the retina to bright light, may continue for months, e. g. until winter, and may return again in spring.

In recent cases or after a good night's rest it does not appear in the forenoon, though the day may be dull; while after midday, with the same degree of light, it becomes felt. The result of ophthalmoscopic examination is negative in many cases. Choroido retinitis and its effects, or hyperæmia of the optic disc and retina, may be found.

As causes are mentioned—1. Various forms of choroido retinitis and other intra and extra ocular morbid changes which affect the periphery of the retina. 2. Scurvy and ague, of which the night blindness may be the only symptom. 3. Exposure of the retina to direct, or to reflected sun, or moonlight. Night blindness has appeared as an epidemic among soldiers and sailors, though all exposed to the same causes may not have suffered. It is more frequently observed in spring.

Treatment. (See treatment of the various forms of choroido-retinitis.)

If night blindness occurs during or after ague, one grain doses of camphor (three times daily) can be recommended. Complete exclusion of light (if night blindness follows exposure), for from one to five days, and good diet, remove hemeralopia, though they do not prevent relapse.

(7.) *Snow blindness* is observed in many persons, and in animals exposed to the white reflection from the snow at the beginning of winter. Vision may be reduced to perception of light. Snow blindness subsides spontaneously, and has been known to act beneficially in cases of anæmia of the retina.

(8.) *Amaurosis or amblyopia from over-use of the eyes, through fine work, microscopic or telescopic work, or from sudden exposure to strong light (lightning).*

The region of the yellow spot is the part usually impaired.

With the ophthalmoscope we may find choroido-retinitis. Exposure to strong light has even given rise to ophthalmitis of the exposed eye. In other cases no changes are discoverable within the eye with the ophthalmoscope.

Anomalies of vision which are caused by extra-ocular, and especially by cerebral causes, often present no marked objective symptoms beyond the impairment of vision. The eye, the vision of which is disturbed, may appear quite healthy, or there may be but slight alteration in colour of the optic disc.

To decide upon the prognosis and treatment of such cases it becomes necessary to examine other functions of the body.

The following are symptoms which frequently precede or accompany the cerebral lesions which give rise to impairment or loss of vision :—

Headache.

The headache in itself is no guide as to the cause and seat of the lesion which may have given rise to impaired vision. It may precede the impairment of vision for years, and is attributed to morbid changes in the dura mater.

Anæmia and atrophy of the optic discs of both eyes are the changes which are finally observed with the ophthalmoscope.

Vomiting.

We should ascertain what kind of vomiting there has been ; whether of bile (the age of the patients attacked by this kind of vomiting varies as a rule between eighteen and thirty),—or of blood (the age of the patients varies between forty and fifty). We should also inquire whether there has been obvious cause for it, or whether it has appeared after meals, or at any other time. The vomiting may be a reflex action, which ceases as the ocular changes progress; or it may be connected with morbid changes about the medulla oblongata, or at the roots of the eighth nerve.

Vomiting and headache with amblyopia or amaurosis are, as a rule, signs of cerebral disease. Inflammation of the optic discs of both eyes is the morbid change which is frequently found on ophthalmoscopic examination.

Giddiness is often complained of, long before lesions of vision occur, by persons suffering from heart disease with intermittent pulse, or from rigid arteries, or from derangement of the circulation in consequence of cerebral changes.

Convulsions, (*"epileptic fits"*) of otherwise healthy, or of paralysed parts.

Neither the character nor the frequency of the fits is a guide as regards the nature of the lesion which may have given rise to defective vision. If confined to one side, we may suspect the cause of impaired vision to lie near, or at the corpus striatum. The fit is sometimes preceded by complete blindness; the latter is attributed to temporary anæmia of the retina from spasm of the coats of its blood-vessels.

Hemiplegia is a frequent forerunner or companion of disturbances of vision. If the two appear simultaneously, they are attributed to apoplexy near, or in the corpus striatum, or thalamus opticus. If the hemiplegia precedes the amaurosis for a long time, then we may attribute the latter to secondary cerebral lesions, or if it occurs suddenly, to fresh apoplexy. In amaurosis with hemiplegia of the right side, and with loss of speech, both hemispheres have repeatedly been found diseased.

Amaurosis, when occurring on the same side as the hemiplegia, is attributed to embolism. Amaurosis from inflammation of the optic discs of both eyes, without anomalies of locomotion, is generally complicated with, or caused by, lesions of the cerebellum or of the hemispheres.

Ataxy of locomotion.

Fourteen patients suffering from this anomaly, all of middle age, have come under observation within the last four years. They complained at first of great general weakness (including that of the genital organs), of a sensation of "pins and needles" in the lower extremities, and of numbness, accompanied by a painful feeling of constriction of the chest. Then followed cramps in the feet and trembling of the hands, especially when attempting to seize objects. Two months after the first symptoms of "ataxy" had appeared vision became impaired, a mist "appearing before the eyes, and gradually getting thicker." The blood supply to the retina and choroid remained normal, but the optic discs rapidly became anæmic, and remained so even in the cases in which the acuteness of vision rose from $\frac{1}{18}$ to $\frac{1}{5}$.

The treatment of these cases by nitrate of silver has been attended with

favourable results. The nitrate of silver is supposed to have restored the normal relation between the optic nerve fibres and the nerve cells in the corpora quadrigemina.

In the cases in which there was no perception of light no effect was produced, while in the patients who could still read large letters the acuteness of vision rapidly (within from four to ten days) increased. After six weeks all signs of the ataxy had disappeared.

The nitrate of silver is given twice daily, in doses of a quarter of a grain, gradually increased to one grain.

Causes of Amblyopia and of Amaurosis.

(1.) *Ocular (in the Retina, Choroid, or Optic Nerve).*
(2.) *Extra-ocular (orbital).*
(3.) *Cerebral or spinal.*

Cerebral changes accompanied by great disturbance of the circulation within the head (as observed during rapidly growing cerebral tumours, and during meningitis), are often complicated with hyperæmia of both the retinæ, with rupture of retinal blood-vessels, swelling of the optic discs, &c. Anæmia and atrophy of the optic nerves are usual changes observed during certain chronic cerebral changes. Such cerebral changes may be far away from the optic nerve fibres, and yet, through pressure, &c., impair their functions. There may be extensive disease of the hemispheres with perfect vision. Morbid changes of the right hemisphere are more often complicated by amaurosis.

Changes confined to one side of the brain may cause hemiopia, but never complete amaurosis.

Amaurosis or Amblyopia (a) from intra-cranial and cerebral tumours.

The usual seat of such tumours is the basis cranii, especially the sella turcica and the neighbourhood of the cerebellum.

Loss of vision is produced either by pressure, impeding the functions of the optic nerves or the circulation, or by complication with inflammation of the optic nerves, with meningitis, &c.

The most frequent changes observed with the ophthalmoscope in the course of cerebral tumours are—hyperæmia,—œdema,—inflammation of the optic discs and retinæ,—anæmia, or anæmia with atrophy of the optic discs. Slight protrusion of the eyeball, with fulness of the veins about the eyelids, is an occasional complication of tumour at the sella turcica, or at other parts of the basis cranii.

Amaurosis or Amblyopia (*b*) *from morbid changes at the base of the brain.*

The most frequent change observed is meningitis (tubercular, pyæmic, typhoid). In some cases the impairment of vision appears at the time of the meningitis; in many long after the meningitis has passed. Both optic nerves, or one, or only part of one, may be affected. Amaurosis of both eyes in these cases is generally complicated with paralysis of other cerebral nerves.

Amaurosis or Amblyopia (*c*) *following apoplexy, or softening, or tuberculosis, or abscess of the brain.*

The lesion of vision is often complicated with paralysis of separate spinal nerves, or of other cerebral nerves with hemiplegia or paraplegia. Apoplexy is a frequent cause. It may appear simultaneously in the eye and brain. Monolateral hæmorrhage into the thalamus opticus causes hemiopia. To produce blindness hæmorrhage must occur on both sides. Hæmorrhage into the chiasma may cause blindness. When occurring at other parts of the basis cranii it generally affects the third nerve also.

Amaurosis (*d*) *from constriction of both optic nerves* (causing indentation or partial or total destruction) *by the two arteriæ communicantes posticæ.*

Amaurosis or Amblyopia (*e*) *following injuries,* especially blows or falls causing concussion of the brain.

Pain in the head, fits, and peculiar anomalies of locomotion frequently accompany the impairment of vision. All hope of recovery of vision is lost if once atrophy of the optic disc and retina has set in.

Hereditary Amaurosis or Amblyopia (*f*) *from incomplete development of the brain or eye* (*Microphthalmus, Hydrophthalmus, Coloboma*), *or from morbid changes appearing in the brain, as Hydrocephalus, or in the eyes during growth or in advanced life.*

In hydrocephalus the tracts of the optic nerves, which run below the crura cerebri, are unduly stretched during distension of the ventricles by fluid. The thalami optici and crura cerebri are pressed asunder. The floor of the third ventricle, the tuber cinereum, the chiasma, sella turcica, and the adjoining part of the sphenoid bone, likewise suffer from the distension. Atrophy following choroiditis, and anæmia and atrophy of the optic discs and retinæ, are frequently observed simultaneously.

Simulation of Amaurosis or of Amblyopia (1) *of both eyes.*—This has been observed in insane persons, and in others with a view of obtaining a cer-

tificate of blindness. Simulation may be suspected if both pupils are active, and if it is stated that light cannot be perceived. We may be unable to express an opinion if the person only denies the power of recognizing objects.

Simulation of Amaurosis or of Amblyopia (2) *of one eye, generally of the right.* If the pupil of the supposed blind eye (provided it be not under the influence of a mydriatic, and the fellow eye be thoroughly excluded from light) does not contract when suddenly exposed to strong light, but does so when both eyes are open, we can pronounce the first eye to be blind. We should, if any doubt remains, after having carefully examined the "supposed" blind eye, place a strong prism, e. g. one of 12°, with the refracting angle downwards before the good eye. The patient is directed to look at the flame of a candle, when the simulation at once becomes apparent if he states that he sees two flames (attributing them to the action of the prism on the sound eye).

Amaurosis or Amblyopia (g) with disease of the spinal cord.

Tenderness on pressure in the region of the first cervical vertebra, with impairment of vision, has been observed to precede the amaurosis.

The ophthalmoscopic symptoms in advanced cases are anæmia and atrophy of the optic discs and retinæ. The atrophy of the optic discs is in some cases the first of a series of symptoms arising from spinal changes.

Much benefit has been derived in some cases from repeated blisters applied to the cervical region.

The post-mortem examination of some cases has shown atrophy of the trunks of the optic nerves, and morbid changes, e. g. atrophy in the thalami optici.

As causes have been observed injuries, inflammation, atrophy.

Reflex Amaurosis (h) from "irritation," originating in one of the sensitive nerves, or from "irritation" of other parts of the nervous system.

Cases belonging to this group occur not unfrequently without any apparent changes in the eyes (the optic discs among other parts appearing healthy), or in the functions of the cerebrum or cerebellum.

The amblyopia or amaurosis is attributed to alterations in the tubercula quadrigemina; which alterations are supposed to be the result of "irritation" elsewhere, e. g. of injuries to the spinal cord, of irritation of the frontal nerve, of neuralgia of the face, of gastralgia, of irritation caused by worms.

The disturbance of vision following such irritation, the increase or decrease of vision keeping step with the irritation, and improvement of vision on cessation of the supposed cause, justify the assumption of a reflex amaurosis.

Amaurosis or Amblyopia (i) from general or constitutional causes.

(1.) *Appearing among other symptoms of Albuminuria.*
(2.) *During Syphilis.*
(3.) *During Diabetes mellitus.*
(4.) *Through Embolism.*

The morbid changes comprised under (1), (2), (3), and (4), when localizing themselves in the eyes, assume certain characteristic forms, e. g. that of effusion of lymph in syphilis, that of peculiar infiltrations with rupture of blood-vessels in albuminuria, &c., &c. If on the appearance of amaurosis or amblyopia we find the eyes intact, and, after examination of other organs, discover albuminuria, syphilis, &c., we adopt the same general treatment which would have been carried out if the eyes had been attacked.

Amaurosis or Amblyopia (k) appearing during irregularities of menstruation, during pregnancy, parturition, or lactation.

Sudden amaurosis, appearing about the time when menstruation has been expected, has been observed in two cases to subside again after the reappearance of that function. Vision returned gradually in both cases, and has remained normal.

Cases of recurring amblyopia or amaurosis commencing at some period of pregnancy, and subsiding after parturition, have repeatedly been recorded.

A frequent cause of amblyopia or amaurosis after sudden arrest of menstruation is the occurrence at that period of intra-ocular or of cerebral hæmorrhage, which has been preceded in several cases by severe pain in the head with unconsciousness.

The morbid changes, which give rise to lesion of vision during the above changes in the body, in many respects resemble those observed during albuminuria, and may be divided into three groups: (1.) Cases in which the chief symptom is hæmorrhage within the eye, with œdema of the parts adjoining the seat of hæmorrhage; (2.) Cases in which infiltration (inflammation) appears with the subsequent changes of texture (generally at and near the optic disc); and (3.) Cases in which no lesion is discoverable within the eyes.

Amaurosis or amblyopia (l) from anæmia (ischæmia).

1. Anæmia from general causes, e. g. from diabetes, diarrhœa, spermatorrhœa, loss of blood. Vision in these cases is lost, in some gradually, in others suddenly. Much good may be done, if the impairment is not considerable, by improving the general health; while if the ophthalmoscopic signs of atrophy of the optic nerve and retina have appeared (and the

sooner the worse) little hope remains, though the general health may have been restored.

Vomiting of blood has been accompanied or followed by sudden loss of vision of one eye or of both. If one eye only is affected the other generally becomes impaired in from one to six months later. Vision in such cases, if lost suddenly, often remains lost, though the general quantity of blood may have been restored. The anæmia and atrophy of the retina and of the optic disc appear at a later period. There may have been amaurosis for some time, while with the ophthalmoscope we find only slight anæmia or no changes at all. The loss of vision is not explained by the quantity of blood lost, nor by anæmia of the brain, since other cerebral functions return as the quantity of blood increases.

The amaurosis sometimes appears while the patient is recovering from the loss of blood. In some cases the loss of blood has been so slight that the amaurosis could not be attributed to it.

Several of the patients suffered from ulceration, with sloughing of the mucous membrane of the stomach. Their ages varied between 40 and 50.

2. Amaurosis or amblyopia from anæmia from local causes.

Gradual compression of the artery of the retina is followed at first by impairment of the functions of the retina in the region of the yellow spot. Sudden obstruction causes sudden amaurosis. The less arterial blood enters the retina the more is vision impaired.

Amaurosis or Amblyopia (m) produced by tobacco, or lead, or quinine, or alcohol.

These substances often produce spasm, or paresis, or paralysis of the ciliary muscle; and we must guard ourselves against mistaking for amblyopia or amaurosis the disturbances of vision due to these conditions.

By tobacco.

The patients generally are of middle age, thin, of pale yellow complexions, and rarely complain of pain in or about the eyes. They generally state that the impairment of vision has progressed slowly. Vision may, however, within six months be reduced to mere perception of light. The impairment of vision (if the disease is progressing) reaches this degree in from six to eighteen months. Both eyes are affected, though in varying degree. One eye may become blind without the patient being aware of it. Night blindness and decrease of acuteness of vision for distance are often the earliest objective symptoms. Photopsia frequently appears, and sometimes after all vision is lost.

With the ophthalmoscope we observe at first hyperæmia of the

optic disc, with anæmia of the retina. Anæmia and atrophy of the optic disc and retina finally follow. The greater the diminution in the number of arteries in the retina the greater is the impairment of vision. Post-mortem examinations have shown traces of basilar meningitis which has affected the optic nerves, and also the third and facial nerves.

By lead.

Impairment of vision from medicinal application of lead has been observed in two cases, and from working with lead in several cases. In the former, protracted headache was followed by sudden loss of vision in the right, and, twenty-four hours later, in the left eye. This was complicated with paralysis of the ciliary muscle and iris, and with some increase of temperature. In one case vision returned after the use of mercury (to salivation) followed by that of Iodide of Potassium. In one of the latter cases no morbid changes, except extreme anæmia, were discovered on post-mortem examination.

By quinine.

Deafness and noises in the ears are usual complications. With the ophthalmoscope we find a tortuous condition, or at least an over-fulness of the veins of the retina in the otherwise healthy eye. Much benefit has been derived from repeated bleeding.

By alcohol.

In one case, in which vision was reduced to mere perception of light during prolonged abuse of alcohol, the optic discs appeared healthy. Vision, after drinking was discontinued, and leeches had been applied to the temples, returned rapidly, so as to allow the patient to follow his employment.

Amblyopia of one eye (n) from non-use after prolonged exclusion.

This form of amblyopia reaches a high degree only if it be congenital, or of very long standing. It may remain undiscovered for years.

Cases have occurred in which the functions of the retina of one eye have seemed to interfere with those of the fellow eye. In these cases direct vision of one eye gradually became impaired. The development of higher degrees of amblyopia seemed to be prevented in some of these cases by the pupil becoming closed or cataract developed. Paralysis or paresis of the iris, and of the accommodation, opacities of the cornea, and especially strabismus of one eye, are usual complications.

INJURIES OF THE RETINA AND OF THE OPTIC DISC.

The retina readily undergoes suppuration together with other tunics during ophthalmitis after injury. During operations on the deeper parts of the eye, the retina may be wounded; or it may become lacerated by foreign bodies passing through it without the ensuing inflammation extending beyond the seat of injury. (See Retinitis, Ophthalmitis, and Injuries of other Tunics, and of the Vitreous Substance.)

Concussion by blows, &c., may be followed by displacement of the retina, or by rupture of its blood-vessels, or by glaucoma, or by ophthalmitis, or by a combination of these.

The changes of the retina, as seen with the ophthalmoscope, have appeared in many cases of concussion confined to the blood-vessels. These, especially the veins, have appeared more numerous and unequally dilated, and more so if the injury has given rise to hæmorrhage into the vitreous chamber. In the majority of cases the arteries and veins have been found abnormally thin, and have remained so for months; while those of the fellow eye have appeared more numerous, and, on the slightest pressure, have shown pulsation.

The optic disc, as a rule, appears unduly vascular, and sometimes as red as the choroid.

This is occasionally followed by anæmia with some atrophy if inflammatory changes have appeared in or near the optic nerve.

Rupture of the choroid near the optic disc, leaving a bluish-white cicatrix, is an occasional complication.

Traumatic choroido-retinitis round the optic disc, with or without inflammation of the latter, has in several instances led to complete loss of vision, without externally altering the appearance of the injured eye.

Hyperæmia of the Retina (see Plate VII. Fig. 13).

The examination of numerous healthy eyes, the comparison of the two eyes (if this condition is confined to one eye), and the general appearance of the patient, are in slight cases the guides as to the existence of hyperæmia of the retina. An increase in the number both of arteries and of veins, with an unusual brilliancy of the retina and hyperæmia of the optic disc, is observed in hypermetropics with asthenopia, and in myopics with signs of irritation. Hyperæmia of the retina often appears during severe inflammation of other parts of the eye, and occasionally in cases of protrusion of the eye from extra-ocular causes.

Overfulness of the veins of the retina—venous hyperæmia—is observed

in persons suffering from syphilis or albuminuria. It also precedes inflammation of the optic disc, and appears whenever the return of blood from the retina is impeded through pressure upon the optic disc or upon the optic nerve inside or outside the eye.

The arteries generally appear thin and fewer in number, while the veins are large, tortuous, numerous, and most conspicuous in and near the optic disc.

Venous hyperæmia also precedes and accompanies inflammation of the retina.

RETINITIS (INFLAMMATION OF THE RETINA. DYCTITIS).

Retinitis is very rarely idiopathic. As a rule, it appears as one of the symptoms of other morbid changes, such as albuminuria, syphilis, cerebral tumours, &c.

Retinitis appears very frequently in both eyes simultaneously, though it may vary in degree ; it most frequently occurs in the part of the retina which adjoins the optic disc, and in the portion which occupies the region of the yellow spot.

Peculiarities as regards colour and shape or situation of the inflamed portion have given rise to the distinction of various forms of retinitis. These forms, if fully developed, are sufficiently characteristic to allow of recognizing the general morbid change, of which the retinitis is a symptom.

FORMS OF RETINITIS.

To facilitate reference we will number the different forms.

(1.) *Retinitis extending from the optic disc over a varying area of the retina.* (See Plate VI. Fig. 9.)

The retina, together with the entire optic disc, or with part of it, appears hazy, grey, or grey-white and opaque. A similar change may simultaneously be found in the region of the yellow spot. The arteries appear thin, and fewer in number. The veins are tortuous, gorged (pale red in the leucæmic form, dark red in the form which complicates cerebral tumours). (See Inflammation of the Optic Disc.)

(2.) *Retinitis apoplectica.*

An unusually large number of blood-spots (many of which lie close to gorged tortuous blood-vessels) appear in the turbid retina, especially at and near the optic disc.

(3.) *Retinitis with yellow or buff or rust-coloured spots, or patches.* (See Plate X. Fig. 31.)

This form of retinitis appears by preference in the region of the yellow

spot and round the optic disc, and is generally accompanied by marked decrease of blood supply to the retina.

(4.) *Retinitis pigmentosa.* (See Plate VII. Fig. 18, and Plate VIII. Figs. 19, 20.)

(5.) *Retinitis with one or several large grey and opaque patches.* (See Plate VII. Figs. 13, 14.)

This form of retinitis occurs more frequently at some distance from the optic disc or near the ora serrata. Small blood-spots, with increase in the number of arteries and of veins (which are particularly conspicuous in the optic disc), are observed in the retina; the retina adjoining the inflamed portion is œdematous. The vessels in the further course of the disease gradually resume their natural calibre, though an overfulness of the veins often continues long after the retina has resumed its transparency. The blood-spots and the opaque patches disappear, the retina gradually becomes transparent, and the choroid becomes visible. Some atrophy of the retina, with slight anæmia of the optic disc, generally remains.

(6.) *Suppuration of the retina.*

The retina rapidly (in from twelve to thirty-six hours) becomes yellowish-white, opaque, and swollen, especially round the optic disc and in the region of the yellow spot, where its thickness may be three or four times that of the retina in health. This swelling and the loss of transparency are caused by the presence of pus cells, exudation corpuscles, &c. The pus cells and the exudation corpuscles are supposed to originate in the nuclei of the fibres of the framework of the retina.

The outer surface of the suppurating retina in many instances has a uniform red colour from the extreme capillary vascularity developed in it.

Hypertrophy and excrescences of the connective tissue and of the membrana limitans appear in the further course of the affection, and assist in the destruction of the nerve elements (ganglion cells, granules, &c.); the granules become ill-defined, paler, and finally disappear. The retina, in from six weeks to three months, is reduced to a semiopaque, or opaque membrane which, thrown into folds, extends from the optic disc to the ora serrata; very rarely does it, after suppuration, remain in apposition with the choroid; in any case it becomes atrophic.

Causes and general Remarks.

1. Retinitis (5) has been observed after sudden exposure of the retina to bright light, and after undue prolonged exertion. The retinitis in these cases is often confined to the injured eye, and more often to the region of the yellow spot.

2. Retinitis (5) and (6) occur after injuries and operations (see Ophthalmitis).

3. Retinitis (5) and (6) often appear after general illness, such as scarlatina, measles, smallpox, &c., or during pregnancy, suckling, &c.

4. Embolism, albuminuria, diabetes, diseases of the heart and arteries, frequently give rise to retinitis (1), (2), or (3).

5. Syphilis gives rise to retinitis (1) or (3).

6. Intra-ocular causes of retinitis are choroiditis, inflammation of the optic disc, cyclitis, rupture of blood-vessels ("retinitis apoplectica"), tumours, and entozoa. These causes generally lead to retinitis (5) or (6).

Retinitis with much loss of transparency of the retina is often followed by atrophy. The retinitis may remain stationary, or may decrease (according to the habits, occupation, &c., of the patient); or it may progress rapidly to a certain point and then become chronic. The longer the duration the less favourable is the prognosis. Retinitis is frequently accompanied by choroiditis.

Symptoms common to all or to several of the above forms of retinitis:

1. Loss of transparency varying from slight haziness to a uniform grey and opaque colour.

In the opaque portion we often find blood-spots, or yellow and opaque spots (as in albuminuria), or rusty-coloured or yellowish-white nodules (as in syphilis). The lesions of transparency are most conspicuous in the region of the yellow spot and round the optic disc, and together with anomalies in the circulation, are characteristic of retinitis.

2. Alterations in the appearance of the blood-vessels.

In most forms of retinitis we find an apparent decrease in the number and size of the arteries, and a gorged, tortuous condition of the veins. Portions of these latter are entirely, or more or less, hidden in the opaque retina.

Groups of enlarged capillaries, appearing to the naked eye as blood-spots, are particularly frequent in the retinitis (5) and (6), covering the outer (choroidal) surface of the retina. Blood-spots, the result of rupture of blood-vessels, occur in most forms, but more particularly in (1) and (2).

3. Photophobia, photopsia, chromopsia, with headache, pain in the eye, and with lachrymation, may appear in the beginning or in the further course of the disease, or may be entirely missing; or only one or several of these symptoms may be present.

4. The exterior of the eye (the eyelids, conjunctiva, cornea, &c.) presents nothing characteristic of retinitis. In suppuration of the retina we generally observe those changes which appear during ophthalmitis, as chemosis,

swelling of the eyelids, protrusion of the eye from œdema or inflammation of the parts within the orbit, &c.

5. Vision. No impairment of vision may be observed by the patient if the inflammation occupies only peripheral parts of the retina, or if it is confined to one eye only, or if the occupation of the patient does not require acute sight.

We often find entire loss of transparency of the retina with very slight impairment of vision, probably because the changes are in that stage confined chiefly to the connective tissue of the retina.

In slight degrees, or at the outset (when the inflammation occupies the region of the yellow spot or of the optic disc), objects appear to tremble, or glitter, or seem distorted, or surrounded by a grey-white, or brownish, or yellowish or red mist. Much light is required for vision, and objects have to be held closer.

In higher degrees interruption or limitation of the field of vision is observed. Vision may become reduced to bare perception of light rather suddenly, and then decrease or improve gradually.

The impaired portions of retina are generally ill-defined. They are described as black or grey patches, by the patient, when looking at a sheet of white paper held close to the affected eye.

The prognosis, as regards recovery of vision, is less favourable if there is interruption or limitation of the sensibility of the retina, than if the entire retina is more uniformly impaired. The longer the duration of the retinitis the worse the prognosis. Dark spots in the field of vision may clear up in some parts more than in others, or may disappear entirely.

Treatment.

For the treatment of the forms of retinitis (1), (2), (3), and (4), see articles on the several subjects.

Treatment of form (5).

Both eyes must be kept thoroughly at rest until all hyperæmia has disappeared from the retina and optic disc. This is effected,

1st, By keeping the lids of both eyes closed during the day if there is intolerance of light: we simply prohibit the use of the eyes for near work if there is no intolerance.

2nd, By ordering atropia to be applied twice daily, and tinted spectacles to be used if the atropia should give rise to intolerance of light.

3rd, By avoiding everything that might derange the circulation in the retina, such as travelling in a carriage, stooping, occupations causing excitement, &c.

4th, By bathing the closed eyelids with cold or warm water, according to the liking of the patient, and as often and as long as is pleasant.

One or two leeches to the temple on the side of the affected eye, applied at bed-time, relieve pain if it be accompanied by much hyperæmia of the inflamed part.

The retina and optic disc should occasionally be examined with the ophthalmoscope. A glance will suffice to ascertain their condition. When once the retina has become transparent, and the choroid again visible, little further improvement of vision can be expected.

The general hygienic and medical treatment must be directed according to the cause of the retinitis, and the health of the patient.

Mercury has been found of use in retinitis occurring during pregnancy. Tonic treatment is adopted when the retinitis has appeared during or after smallpox, measles, and similar weakening diseases. This form of retinitis in weak persons often goes on into suppuration. (See also the treatment of Choroiditis.)

ATROPHY OF THE RETINA.

The cause of the atrophy in a great measure determines the kind; and again, the different kinds point to different causes. With the ophthalmoscope, and on minute examination, we can distinguish four different forms.

No. 1 (see Plate VI. Fig. 7). No morbid changes are perceptible in the choroid nor in the transparent retina beyond an extreme anæmia of of both tunics, or of the retina only.

Anæmia of the choroid (the groups of stellate pigment cells being visible throughout the choroid) may be mistaken for atrophy of that tunic by those who are not familiar with the colour and shape of these groups in health.

The retinal arteries and veins are thinner the farther they are from the optic disc. They are tortuous and unequally dilated. The optic disc is anæmic, or anæmic and atrophic. It has a waxy-white and opaque colour.

No. 2 (see Plate VII. Fig. 17). This form is described as one of the sequels of inflammation of the optic disc. It is the conjoined result of an impeded blood supply to the retina, and of impaired nutrition through arrest of the function of the optic nerve. (See Inflammation of the Optic Disc.)

No. 3 (see Plate VII. Fig. 18; Plate VIII. Figs. 19, 20; Plate X. Figs. 35, 36). Atrophy following retinitis or choroido-retinitis. The optic disc may be anæmic or atrophic, or highly hyperæmic. Its margin, according

to the changes in the choroid and retina, is either well-defined, or its colour merges into that of the tunics.

In addition to the decrease in the number and calibre of the arteries and veins, we meet with changes in the transparency of the retina, and with morbid pigmentation. Large arteries, though empty, can often be traced into the retina as whitish opaque lines. Some of the remaining veins appear varicose. The blood-vessels, according to the degree of atrophy, become thinner the farther they are from the optic disc. Many can be traced a short distance into the retina, others disappear in it close to the optic disc. In high degrees none may be visible in the optic disc; or a very few thin ones may be seen extending slightly into the retina. The retina is semiopaque in some (especially round the optic disc), transparent in other parts. The opaque portions shade off into the transparent ones. The black and brown groups of pigment are the result of choroidal changes; the retina (i. e. the tissue occupying its place) may be unusually transparent, so that the light and dark brown pigmentation of the anæmic choroid is well seen, and presents a very striking appearance when contrasted with that of health.

Causes and general Remarks.

Atrophy of the entire retina, or of portions of it, the result of old age, is very rarely observed to such an extent as to be regarded as morbid. In the few cases which have occurred the appearances were those described as "retinitis pigmentosa."

The following changes lead to atrophy of the retina—

1. Any of the lesions which for a long time prevent retinal impressions from reaching the brain, such as diseases of the brain or of the optic nerves. The atrophic changes described as form No. 1 in these cases appear late and progress very slowly. A certain amount of atrophy may disappear again if the extra-ocular lesion subsides.

2. All changes which mechanically cause anæmia of the retina, such as embolism, inflammation of the optic disc, cupping of the optic disc, increase of tension.

3. A large series of intra-ocular changes, which may be separated into (*a.*) Those which commence in the choroid, leading to atrophy of that tunic, and, secondarily, to atrophy of the retina; or which, during choroiditis, invade the retina, destroying it from its outer surface (form No. 3); and (*b.*) Those which commence in the retina subsequently to retinitis (form No. 3), or which are caused by pressure of the contents of the vitreous chamber upon the retina, destroying the latter from its inner surface (form No. 2).

RETINITIS DURING ALBUMINURIA (see Plate XV. Fig. 31).

Retinitis may appear whenever albumen is present in the urine: it is most frequently observed in patients suffering from Bright's disease. Retinitis in these cases has been considered a forerunner of albuminuria. On careful examination, however, it will be found that alterations in the kidneys have existed long before, though the symptoms may have been so slight or progressing so slowly that the retinitis has become the first prominent symptom of the kidney disease.

When meeting with this form of retinitis we must be prepared to see other uræmic symptoms make their appearance, though they need not necessarily follow.

"Granular kidneys," with dilatation of the cavities of the heart, and with hypertrophy of the left ventricle, have been found, not in all, but in most cases in which post-mortem examination could be obtained.

Vision.

From the analysis of thirty-eight cases it appears that in albuminuria two chief causes of impairment of vision may be distinguished. The rarer one is uræmia, the more frequent one retinitis.

A combination of the two has occurred. Out of thirty-eight cases thirty-two suffered from retinitis.

The loss of vision in those presenting symptoms of uræmia has been very rapid; the patients have become blind suddenly, have remained so for from a few minutes to a few hours, and then have quickly recovered vision again. Vision, though for a time remaining normal after the first attack, has been observed to fail again gradually in those cases in which pain in the head, dizziness, convulsions, or paralysis may have appeared as complications.

The impairment of vision caused by retinitis is not so sudden as in uræmia. It increases gradually for a time, varies in degree, and (the region of the yellow spot being generally implicated) is perceived at once. Yellow spots impair vision more than opaque, grey, and white ones. The former often intervene between the rods and the rest of the retina, and lead to destruction of that part of the retina. The patients complain of a mist obscuring objects. Objects are seen more distinctly when held on one side, &c. Any other form of retinitis, affecting similar portions of the retina, may give rise to similar modes of impairment.

Changes in the Retina.

We distinguish those changes which occur also in the course of other

forms of retinitis, and those which are characteristic of this form. The former changes are hyperæmia, and subsequent swelling and loss of transparency of the retina. The characteristic symptoms are brilliant yellowish-white and opaque spots round the optic disc, and in the region of the yellow spot.

The hyperæmia shows itself by a fullness and tortuous course of the numerous, sometimes distinctly pulsating, veins of the retina (with comparatively few and thin arteries), and by a red optic disc. This stage may subside, and no retinitis follow. If retinitis appears, it does so first round the optic disc.

The retina round the optic disc then becomes swollen and opaque, or semiopaque, and sprinkled with blood spots. The opaque portions gradually shade off into the more healthy ones.

The optic disc, when participating in the swelling and loss of transparency, loses its defined margin. Its position can often only be inferred from the vessels of the retina converging towards it. These vessels cannot generally be traced into the optic disc; they appear much diminished in number.

In the retina, round the yellow spot, a similar impairment of transparency is observed; the yellow spot often appears as a red, or brownish-red, ill-defined dot in the hazy retina.

Round the foci of inflammation we find—solitary or in groups—spots of inflamed retina, which vary in size. The course of the blood-vessels is more or less obscured in the inflamed portions of the retina. The blood spots may be so numerous or so large as to hide a considerable portion of the retina from view. The blood, by perforating the retina, may escape into the vitreous chamber and give rise to opacities; or it may accumulate between the choroid and retina, and (as occurred in three cases) lead to displacement of the retina. Some of the blood spots are round, others oval or streaked. The streaked ones generally appear first, and are situated immediately beneath the optic nerve-fibres. This stage of retinitis (the swelling, loss of transparency, and blood spots) having continued for some time, the characteristic brilliant yellowish-white, or buff-coloured and opaque spots appear in the grey swollen retina. In the region of the yellow spot they generally appear in groups, and have a somewhat linear arrangement, which gives this part of the retina a striated appearance. The spots round the optic disc soon run together into one or several larger brilliant yellow patches which surround the disc, or skirt it on one side, or are separated from it by a narrow grey and opaque band of retina. The number of the spots varies; one only, or a few may be found round the optic disc or in the region of the yellow spot; or the retina round the optic disc may be thickly sprinkled with them. The margins of the larger ones often are surrounded by blood spots for some time; the large blood-

vessels of the retina may be seen passing over, or by the sides of the spots.

The opacity and swelling of the retina, and the tortuosity and enlargement of its veins, disappear gradually. The outlines of the optic disc become visible again, together with the vessels in it. We may find the yellow spots, which appear in the later stage of the retinitis, alone or mixed with blood spots, while the rest of the retina has regained its transparency.

The spots may become obscured by fresh hæmorrhage. They are easily distinguished from atrophic portions of choroid by their yellow colour, by the frequent simultaneous presence of blood spots, and by the absence of the pigment patches which invariably adjoin completely atrophied portions of choroid.

The yellow spots disappear gradually in from three to six weeks, leaving the retina transparent. We are then able to judge of the changes of the choroid, in which yellow patches, similar to those in the retina, occur; and which, after having disappeared, leave the hexagonal cells disturbed, giving rise to groups of brownish dots and patches upon more or less atrophic portions of choroid. The latter, together with some anæmia of the optic disc and of the retina, are often the only vestiges left of the retinitis.

Dissections of eyes, in various stages of retinitis, of persons suffering from albuminuria, have disclosed the following morbid changes.

The blood spots.—These have been met with in, upon, and beneath the retina. In the retina, especially in the inter-granule layer, the blood has been found accumulated in cavities, formed by displacement of the granules and of the connective tissue of the retina. These structures having become soaked with probably highly-albuminous fluid, and with blood, have undergone secondary changes, such as loss of transparency, fatty degeneration, thickening of the connective tissue, &c. The blood itself, the colouring matter having disappeared, has formed structureless, semitransparent, or yellowish-grey and opaque coagula.

Upon the retina and among the optic nerve-fibres such coagula have been found, side by side with fresh red clots of blood.

Similar yellowish-white and opaque and red clots have been met with in and upon the choroid. The fluid which has escaped from the blood-vessels has probably had a great share in the formation of the yellow patches.

Peculiar changes, by some described as "sclerosis," have been found in the coats of the blood-vessels, especially in those of the small arteries, and of the capillaries of the retina and of the choroid. These vessels have appeared unusually tortuous and flattened in many places, with their walls thickened by a homogeneous, strongly light-reflecting "amyloid," not

quite transparent substance. In some cases the thickening of the walls has caused occlusion of the lumen of the vessels. This may have been the cause of the small aneurismata which have been found in many parts of the capillaries.

The retina and choroid adjoining the thickened vessels in some cases appeared hypertrophied.

The yellow or buff-coloured spots, when situated in the retina itself, were found amongst its ganglion cells, but more frequently in the granule layers. The spots were most numerous round the yellow spot. The thickness of the retina, as could best be seen in sections, was considerably increased.

The yellow spots, when examined by reflected light and with a low magnifying power, appeared yellowish-white, opaque, and roundish; seen by transmitted light they appeared black and opaque. Examined with a high magnifying power in sections they appeared composed of granule cells, of fat globules, of fibrin, and of altered fatty connective tissue. The granule cells had exactly the shape and nearly the size of the granules of the granular layer, with the difference that they were less transparent, contained a larger number of minute granules, and were mixed up with free granules and fat molecules.

The striated appearance of some of the yellow and of other opaque spots is explained by the arrangement of the connective tissue of the optic nerve-fibres and of the retina. This tissue loses its transparency, and undergoes fatty degeneration among the yellow patches of the granular layer. Like the capillaries and small arteries, it presents changes which have been described as hypertrophy and sclerosis; the nuclei and those portions of the fibres which join the inner membrana limitans, and which pass across the layer of optic nerve fibres, become thickened. The fibres, instead of being transparent, are strongly light reflecting, and, if present in large numbers (seen with the naked eye), appear as brilliant white, or greyish white streaks, spots, and patches in the retina, or among the optic nerve fibres. Many of the brilliant greyish white spots, seen during life with the ophthalmoscope, are caused by this thickened ("sclerosed") connective tissue of the retina.

The greyish-opaque or semiopaque appearance of the margin of the optic disc and of the retina (observed in the commencement of retinitis) is the result of "infiltration with serum." The retina becomes swollen. The swelling, if considerable round the optic disc, impedes the passage of blood into and through the disc, and favours the rupture of blood-vessels.

Treatment.

The general medical treatment is that of albuminuria. Much benefit is

derived from large doses of strychnine, combined with steel; and in stout nervous persons from a combination of Mixt. Ferri Co. and Decoct. Aloës Co. āā ℥i to be taken at bed-time.

No advantage has as yet been gained from surgical treatment, such as iridectomy, &c. Rather abundant local depletion (e. g. by applying from six to eight leeches to the corresponding temple) is found of great use in the commencement of retinitis, but is injurious when once the yellow patches have appeared. If these spots and patches are numerous in the retina, or if blood has been effused into the vitreous chamber, atropia should be applied twice daily, and the eyelids should be kept closed by a bandage if one eye is affected, or a shade should be worn if both eyes are attacked.

The local treatment is discontinued as soon as the yellow patches have disappeared. Displacement of the retina, following extensive hæmorrhage, or destruction of the retina through atrophy, &c., is the frequent cause of permanently impaired vision.

The prognosis, as regards recovery of vision, is good if there are but few spots of the retina affected. An improvement may be expected as long as yellow or blood spots are visible.

EMBOLISM, OR BLOCKING UP OF THE BLOOD-VESSELS OF THE RETINA BY COAGULA, ETC.

Loss of vision from this cause is of frequent occurrence. It has been observed in persons who have suffered from disease of the heart, or from aneurism, or from other diseases (e. g. pyæmia, albuminuria) which give rise to embolism in other parts.

Choroiditis, ophthalmitis, and cerebral embolism have occurred as complications.

In a young man who died suddenly of aneurism of the aorta, embolism occurred in both eyes; in the other cases on record it was observed only in one eye.

The sudden loss of vision, together with the changes perceived with the ophthalmoscope, are characteristic. The ages of the patients who have come under observation have varied between twenty-six and seventy.

Vision.—The patients generally state that a coloured cloud or grey mist has suddenly appeared to intervene between objects and the affected eye. This within a few seconds or minutes is followed by complete blindness or by diminution of vision to bare perception of light. In several cases vision was lost during sleep; in none has any useful amount been regained.

The changes observed with the ophthalmoscope in the vessels of the retina, in the optic disc, and in the retina at the region of the yellow spot, are

particularly striking. The optic disc at first appears slightly anæmic. It gradually (in from two to four weeks) becomes white, and at last slightly cupped, and atrophic. No arteries (no blood in the arteries) or only one or two very thin ones, are visible in the optic disc, or in the retina near it. Clots of blood may, however, be seen in some of the arteries, especially in those going to the region of the yellow spot. These clots finally disappear; and greyish opaque lines indicate the places occupied by the arteries. The veins are thin in the optic disc, and somewhat fuller and unequally dilated in the retina, especially at its equatorial region. A peculiar undulating movement, or a momentary advance of a portion of blood from one part of a vein towards another part nearer the optic disc, is observed soon after the embolism has occurred, and again if circulation returns.

The retina adjoining the optic disc becomes slightly opaque. In one case this was the only change observed, besides the absence of blood from the arteries. In other cases the retina in the region of the yellow spot had lost its transparency and assumed a greyish-white and opaque colour, gradually shading off into the transparent part. The opaque portion in each case was about as large as the part of the retina which is occupied by the oblique radial fibres.

In the middle of the opaque portion (the centre of the yellow spot) a small red spot (attributable to the colour of the choroid shining through this very thin part of the retina) is observed. Minute shining opaque spots appear as the general opacity of this region vanishes, and finally the retina resumes its transparency (sometimes within a few days).

The opacity of the retina appears in from twenty-four to sixty hours after the embolism.

Treatment.

No success has as yet been obtained by local means. The transparency of the retina returned unusually rapidly in the cases in which iridectomy was performed, but without any favourable results as regards vision.

In several patients embolism of the retinal artery has been the means of discovering lesions of other parts of the body; and has thus led to appropriate general medical treatment.

RETINITIS PIGMENTOSA (see Plate VII. Fig. 18; Plate VII. Figs. 19, 20).

The term Retinitis Pigmentosa has been introduced into practice, although the pigment changes, so characteristic of this form of retinitis, are chiefly due to alterations of the choroid. Retinitis pigmentosa is often observed in deaf and dumb children, the offspring of parents who are blood relations.

It has occurred in several children of the same family. It has also been observed in persons who have suffered severely from ague, and in their children.

In some cases the first symptoms have appeared as late as the age of fifty, the patients still retaining perception of light at the age of seventy. This retinitis has hitherto always been observed in both eyes of the same person, though it has varied in degree in the two eyes.

Vision.—Two peculiarities of this form of retinitis are the comparatively good direct vision, and the early appearance of night blindness. The latter is not only marked at dusk, but also whenever in the course of the day the light is unusually dull. The loss of vision steadily though slowly advances from the periphery towards the centre of the retina.

Vision, if examined in broad daylight, may appear normal; while in artificial light (which should always be adopted for the investigation) the periphery of the retina is already found impaired. Such patients may for ten or fifteen years be able to read small type, especially with the aid of convex lenses; and yet all the time may not be able to walk safely, in consequence of the more peripheral parts of the retina having been destroyed. For the same reason large letters and large objects are less easily recognized in advanced cases, parts of their images being formed in damaged portions of the retina. Exceptionally a blind zone of retina may intervene between a more peripheral, and a more central sensitive portion; or a central portion may become blind before a more peripheral one.

Other symptoms.—Slight increase of tension; a pupil of medium dilatation, sluggish, or fixed; and often, especially in elderly people of dark complexions, a well-marked greenish reflection from behind the pupil, when viewed with focal light, have been noticed. In the advanced stages of the disease we often find opaque white dots or streaks on the surface of the lens, or a chalky cataract, which latter in several instances has been more or less dislocated.

On ophthalmoscopic examination we observe the characteristic signs of the disease, which are peculiar dark brown or black spots, many of which are star-shaped, somewhat resembling bone corpuscles. These pigment spots gradually become more abundant. Many anastomose with each other, forming a black web. They appear first at, or near the ora serrata; and we should never neglect inspecting this part by making the patient look in various directions. At last they appear round the optic disc. Their shape, their great number near the ora serrata and at the equator of the choroid, their being situated upon somewhat anæmic portions of choroid, and the absence of circumscribed atrophic patches distinguish them from such pigment spots as follow other lesions of the choroid. The groups of stellate pigment cells are unusually well seen in the anæmic choroid (deprived of its hexagonal pigment cells), and give it a honeycomb appearance.

The anæmia of the choroid, the atrophic changes of its capillaries, of its "epithelium" and of the retina, advance from the ora serrata towards the region of the yellow spot, which latter part retains longest a natural appearance.

The optic disc, as soon as the amblyopia is well marked, appears pale pink and somewhat ill-defined. In advanced cases it assumes a dull waxy-white colour; its nerve fibres can be recognized long after the retina has been destroyed. The retinal arteries and veins, in proportion as the atrophy increases, become thinner. The lumen of the arteries becomes narrowed through thickening of their walls. In some cases only one or two thin vessels can be seen passing through the optic disc, and can be traced a short distance into the retina. The retina undergoes atrophy and becomes thinner. At first it is transparent, but it gradually assumes a dull translucent aspect; it again becomes transparent in advanced atrophy.

The appearance of the black pigment spots is invariably accompanied by destruction of the rods and bulbs; but the atrophy of the retina stands in no relation to the number and size of these black spots. There may be but a few of these, while all the rods and bulbs are destroyed; the hexagonal cells and their granules disappear.

The degree of acuteness of vision and the number and size of the blood-vessels in the optic disc are the best guides as to the state of nutrition of the retina. In many places fragments of retina and choroid remain adherent to each other, when, on dissection, attempts are made to separate the two membranes. The rods and bulbs and layers of the retina adjoining them are destroyed first. The presence of the granules of the choroidal "epithelium," in the shape of the characteristic black spots, render it probable that they have been displaced into the retina by morbid changes coming from the choroid.

RUPTURE OF RETINAL BLOOD-VESSELS.—*Effusion of Blood into the Retina* (*"Apoplexy of the Retina," Retinitis Apoplectica*). See Plate IX. Fig. 30, and Plate X. Fig. 31.

General Remarks and Causes.

Effusion of blood into the retina from rupture of the blood-vessels has been observed—

1. After injuries.

2. In the course of changes which tend to impede the passage of blood through the optic disc (as glaucoma, inflammation of the optic disc and of the adjoining retina), or through the orbit (especially when the cause is

situated close behind the eyeball, or at the fissura orbitalis superior). After sudden closure of the jugular veins on both sides.

3. In the course of morbid changes within the eye (as tumours, retinitis, &c.), which give rise to hyperæmia of the retina.

General diseases, which are frequently complicated with bleeding into the retina, are—albuminuria; diabetes; atheromatous changes of the arteries; lesions which give rise to embolism (especially if situated in the sinus cavernosus, and at or near the fissura orbitalis superior); diseases of the heart; disturbances of the circulation in the brain from inflammation, tumours, hydrocephalus, &c.; anomalies of menstruation, and disturbances of the circulation during pregnancy, parturition, and suckling.

General symptoms preceding the effusion of blood may be entirely wanting. Severe headache, dizziness, impairment of vision on stooping, frequent bleeding from the nose, extreme nervousness, are among the symptoms usually complained of. Rupture of blood-vessels in other parts, and the occurrence of apoplexy in other members of the patient's family, are frequently observed.

The left eye is the one most frequently attacked; and the greater number of cases occur in the spring. Rupture of blood-vessels of the retina is often the first symptom of advanced morbid changes of the entire vascular system.

Our attention should at once be given to the functions of the brain, heart, &c., and our treatment should be directed accordingly.

We shall confine our remarks to those cases in which the blood effusion into the retina is the sole, or most prominent change (this change not being complicated by glaucomatous symptoms).

As regards the effusion of blood which may occur during the different forms of retinitis, during glaucoma, and during myopia, we refer the reader to articles on these subjects.

The diagnosis of blood effusion into the retina is made by the aid of the ophthalmoscope. We may be prevented from seeing the retina in consequence of the blood having entered the vitreous chamber, or in consequence of its having spread itself over the retina. The former occurs more frequently after rupture of retinal vessels at the ora serrata, or near the yellow spot; or the blood may perforate the retina towards the choroid, and give rise to one or several large, flat, dark red, well-defined patches, obscuring the uniform red colour of the choroid and displacing the adjoining retina.

Extravasations of blood into the choroid are easily recognized if they are situated in the spaces between the large choroidal veins.

A varicose condition of the unusually dark red vessels of the retina, with some loss of transparency of the retina obscuring the outline of the optic

disc, and small spots and streaks of blood in the retina, have been observed in cases of hæmorrhage between the choroid and sclerotic.

By the shape of the blood spots we may frequently recognize the part of the retina which they occupy. Blood effusions among, or immediately beneath the layer of optic nerve fibres appear as red streaks; those in the retina generally form small roundish spots; a large roundish dot, or a little smear of blood close to the side of a vessel may indicate the spot from which the hæmorrhage has proceeded. One or several of the large vessels of the retina are often seen ending abruptly at the blood spot, or becoming thin suddenly, while on the other side of the spot they appear large. Thus it may happen that the hæmorrhage from one vessel may interfere with the circulation in another. To many of the blood spots no vessels can be traced.

Colour and absorption of the effused blood.—Fresh blood spots have a bright red colour, which changes into a dark, then into a brown red, and at last disappears entirely, leaving the retina transparent, or more or less opaque.

A blood spot of the size of the optic disc, when situated entirely in the retina, may require from two to ten weeks for absorption. It is often accompanied by temporary swelling and loss of transparency of the surrounding retina. The blood spot decreases from the margin towards the centre. We frequently meet with blood spots which do not pass through the usual changes of colour which healthy blood manifests when undergoing absorption; but which rapidly, sometimes within a few hours, assume a buff, or yellowish, or white and opaque colour. It is this rapid change of colour which is so frequently observed in persons suffering from albuminuria.

The retinal vessels may become obliterated or narrowed, or may remain tortuous on either side of the seat of hæmorrhage. Cicatrices in the retina and displacement of circumscribed portions are the changes frequently observed after absorption. The optic disc, at first hyperæmic, resumes its normal colour, or becomes somewhat anæmic. It is not unfrequently the seat of blood effusions. The tension of the eye in profuse hæmorrhage into the retina is increased at first, and slight cupping of the optic disc remains after absorption is completed. The tension sinks below par; and the eyeball becomes soft if the absorption of blood is incomplete, and no effusion occurs.

Vision.—The obscuration of vision is sudden, and varies in kind and degree with the extent and localization of the effused blood.

The manner in which vision farther becomes impaired by the effusion depends upon the part of the retina occupied by the effusion, upon its quantity, and upon the changes which follow in the retina and in the adjoining tunics. The nearer to the yellow spot the effusion the more does

it affect vision, and the sooner is it noticed by the patient. For example, a patient suddenly observes a dark streak or cloud, with a reddish halo round it, "straight in front of one eye:" and, on ophthalmoscopic examination, we find a small dark red and opaque clot of blood in the retina, and in the vitreous chamber adjoining it. The patient also states that, when looking at his hand with the affected eye, he only sees the tips of the fingers and the wrist.

Another patient sees only the tops or the lower parts of objects; and with the ophthalmoscope, we find blood spots on excentric parts of the retina. Or a patient can just see the shadows of objects; and we find the whole of the retina sprinkled with numerous small blood spots. Another sees objects, straight lines, &c., crooked; and we find effusions of blood beneath the retina (from a retinal vessel) with displacement of small portions of retina.

Muscæ, caused by clots close in front of the retina, are often complained of. Photopsiæ are rarely met with in the beginning, or in the farther course of the hæmorrhage.

A rapid improvement of vision is generally observed, unless the blood effusion has damaged the optic nerve or the yellow spot. The prognosis is rendered unfavourable chiefly by the age, and state of health of the patient, and by a tendency to relapse. The portions of retina at the margin of the effusion recover first. Patients at such periods often state that objects appear distorted or crooked, and surrounded by a mist, &c. The effects on vision of solitary effusions, farther distant from the yellow spot, frequently disappear entirely; while those near, or at that spot generally leave vision impaired, but much less so than we might expect at the outset of the attack.

The slight permanent impairment of vision, compared with the extent of the effusion at first, is probably due to the blood passing through the retina, and spreading over it instead of disturbing its structure.

A patient, in whom an effusion of blood (in diameter about $\frac{1}{3}$ of an inch) occurred in the region of the yellow spot, and who could not recognize a hand when held in front of the eye, was able to read small type a year afterwards; there remained a bluish, opaque, and small "blind" spot across the region of the yellow spot.

Better vision is often recovered after absorption of one large effusion than after that of numerous smaller ones.

No changes about the exterior of the eye indicate the presence of hæmorrhage into the retina. Some hyperæmia of the conjunctiva with slight increase of tension is often observed at the outset. The pupil, generally of medium size, acts in proportion to the sensibility of the retina.

Treatment.

The treatment consists locally in the application of a bandage over the closed eyelids of the affected eye; this bandage has to be worn from two to three weeks; if there is no intolerance of light, the other eye may be used with moderation for "near work."

Atropia, applied twice daily until all blood has become absorbed, can be recommended in most cases. No surgical treatment has been found of use provided the tension be normal.

We must, as regards the recovery of vision, be careful when expressing an opinion; partly because the quantity of blood upon the retina and in the vitreous chamber may make us suppose a large portion of retina to have become implicated, while after absorption of the blood in the vitreous chamber we may find the retina but little damaged, and vision normal or nearly so; and partly because the tendency to fresh hæmorrhage prevents our being able to assure the patient of permanent recovery.

The general medical treatment (large doses of the Tinctura Nucis Vomicæ can be recommended) entirely depends upon the general health of the patient, and upon the cause of the effusion. We should look upon the hæmorrhage as a warning regarding the state of the patient's blood-vessels.

DISPLACEMENT OF THE RETINA.

(*Detached retina, subretinal dropsy.*) See Plate X. Fig. 34.

General Remarks and Causes.

The displacement of the entire retina, or of portions into the vitreous chamber is a frequent occurrence; and (injuries excepted) is generally observed in persons beyond the middle age. It is readily recognized by the aid of the ophthalmoscope; and, as a rule, is accompanied by marked disturbance of vision.

The vitreous substance, which in health is of considerable consistence, is remarkable for the rapidity with which it diminishes by pressure from without or within the eye. Tumours of the choroid or accumulations of fluid between the choroid and retina readily cause the vitreous to become less; and the retina becomes detached from the choroid and pushed into the vitreous chamber. Morbid changes of the vitreous substance (formation of pus, cicatrices, &c.) may, on the other hand, cause displacement of the retina by drawing the latter away from the choroid.

Causes.—(1.) Injuries with concussion and subsequent cicatrization or absorption of the vitreous substance. Months may pass before the displace-

ment of the retina makes itself perceptible to the patient, unless it be complicated by effusion of blood into the vitreous chamber. Large perforating wounds are the more likely to be followed by displacement of the retina, the more the wound encroaches from the ciliary region upon the area of the retina. In some instances displacement has occurred six or seven years after the injury.

(2.) Solid or liquid effusions upon the inner surface of the choroid; tumours of the choroid; effusions of blood between sclerotic and choroid, as observed in glaucoma, during irregularities of menstruation, &c. These give rise to absorption of the vitreous substance by pressure, and simultaneously to displacement of the retina.

(3.) Myopia.—The undue distension of the tunics of highly myopic eyes,—a great tendency to effusion of blood,—and anomalies of the vitreous substance, seem to be the causes of displacement of the retina being more common in myopia (and even in both eyes of the same person) than in any other group of cases. We should, in every case of displacement of retina, ascertain the refraction of the fellow eye in order to see whether myopia is present.

(4.) Changes of morbid products (pus, lymph, &c.), which may appear in the vitreous substance during choroido-retinitis. These and the altered vitreous substance gradually shrink, and drag the retina away from the choroid. Foreign bodies, cicatrices, and suppuration of the vitreous substance often destroy vision in this way.

Spontaneous effusions of blood into the vitreous chamber, followed by morbid changes of the vitreous substance round the effused blood, also belong to this group.

Course, diagnosis, and pathology.—The exterior of the eye offers in most cases no peculiarities, though there may be some ophthalmia, or sluggishness of the pupil, or slight divergent strabismus.

The course taken by the retina, when displaced, varies considerably; and little is known regarding the circumstances which retard or accelerate farther displacement. In a few instances, out of a very large number of cases, spontaneous rapid disappearance of the displacement was observed, showing the possibility of the fluid, accumulated between the retina and choroid, being carried off by "absorption."

The rule seems to be that in myopic eyes, especially when occurring in the region of the yellow spot, displacement of the retina proceeds slowest; that in normally shaped eyes it advances more rapidly. On the other hand, spontaneous disappearance or diminution of the fluid from between the choroid and displaced part of the retina occurs very rarely in myopic (enlarged) eyes, and frequently in normally shaped ones.

In cases of displacement of the retina of long standing, chronic iritis,

followed by posterior synechiæ and frequently by cataract, occurs as a secondary change. The eye gradually becomes softer, with very little or no pain, and with slight outward vascularity. Sometimes we meet with increased tension and other glaucomatous symptoms, as fullness of vessels emerging from the sclerotic near the cornea, anæsthesia of the latter, and severe pain in and around the eye. In most cases of this kind, in which the eye has been removed, a tumour, generally springing from the choroid in the region of the yellow spot, has been found besides the displacement of the retina, the latter being one of the symptoms of the tumour.

An examination with the ophthalmoscope (the pupil being dilated by atropia) is necessary in order *to recognize the displacement.*

In well-marked cases we see, on the first glance, close behind the pupil a dark, floating, well-defined substance, more or less intercepting the red reflection. This substance, viewed "directly," is seen in its real place, generally behind the lower margin of the pupil and lens; while examined "indirectly" it appears to be suspended behind the upper margin.

Very small portions of a semitransparent, or larger portions of a transparent, but only slightly displaced ("loosened") retina, can by the experienced observer be recognized by the peculiar dark uniformly red colour and undulating appearance of the vessels of the displaced retina. Larger portions generally are more altered in colour, being semiopaque, or grey and opaque, and floating in some part, generally the lower, of the vitreous chamber. We are not justified in pronouncing a retina displaced as long as we have not succeeded in tracing vessels from the optic disc into the opaque floating portion, nor in recognizing the vessels in the floating membrane by their shape, mode of ramification, &c., as retinal vessels. The vessels appear as dark red, or blackish, well-defined lines, following the undulating movements of the opaque floating substance when the patient moves the eye; while the vessels in the optic disc and in the retina *in situ* have the natural transparent red colour. The displaced retina next to the vessels often presents a peculiar silvery white and opaque colour. In most cases only part of the retina is implicated, though (especially by injuries) any part of the entire retina may become displaced.

Varieties.

(1.) Displacement of delicate folds of retina which radiate from the optic disc. The folds gradually coalesce, as is seen in myopia. Displacement of circumscribed portions of retina by effusion of blood round the optic disc, as seen in glaucoma.

(2.) Displacement of the lower part of the retina, from below the optic disc to the nearest part of the ora serrata. This variety is the most frequent. Its great frequency probably depends upon the fact that, when other parts of the retina are displaced, the fluid settles at the most depend-

ing part of the eyeball between the choroid and retina. The displaced retina may be transparent or semitransparent, so that the choroid and the colour of the fluid between it and the retina can be recognized.

The displaced retina frequently appears silvery white, or greyish and opaque (in old cases yellowish opaque). Its colour in a great measure depends upon the colour of the fluid accumulated between it and the choroid. The extent of the undulating movements of the displaced portion varies during movements of the eyeball. Grey and opaque or brownish red shreads may be seen floating in the vitreous chamber near the displaced retina. The retina, and the choroid adjoining the displaced portion, frequently have a healthy appearance; occasionally a yellow and opaque line in the retina, with or without small blood spots on it, indicates the boundary between the displaced and the healthy retina.

(3.) After injury a fold of displaced retina is frequently observed to extend from the seat of injury (e. g. from a cicatrix caused by a perforating wound of the tunics of the eye near the ora serrata) to the optic disc, while the remainder of the retina continues *in situ* for several years.

(4.) Small folds of any part of the retina may become displaced by tumours of the choroid, or during distension of the eyeball in myopia, &c. A frequent seat of such folds is the region of the yellow spot.

(5.) The retina may become separated from the layer of optic nerve fibres, so that the optic nerve fibres become alone displaced (? through changes of the vitreous substance. See a preparation in the Museum of the Royal London Ophthalmic Hospital, Moorfields).

(6.) The entire retina may be displaced ("funnel-shaped displacement"), and only retain its attachment round the optic disc and along the ora serrata. In cases with increase of tension we may, besides the retina, also find the zonula detached from the ciliary processes.

The retina may not only be displaced from the choroid, but also torn from its attachment round the optic disc. It then becomes puckered up at the hyaloid fossa; and, viewed through the crystalline lens, appears yellow and opaque, and has been mistaken for intra-ocular tumour.

The optic nerve fibres of eyes which have been blind for years in consequence of displacement of the retina while the choroid has appeared healthy, have presented (on microscopic examination) hardly any morbid changes; while in eyes in which cartilage or bone has been formed upon the inner surface of the choroid, the nerve fibres have been missing and their connective tissue atrophied.

All the elements of the retina could be recognized in an eye which had been excised and in which extensive colloid changes of the choroid were found with displacement of the otherwise transparent retina. The rods and bulbs, however, appeared swollen, and in many places they were wanting. Many of the capillaries were varicose, others aneurismal.

The changes found in several eyes, the retinæ of which had become displaced by hæmorrhage between retina and choroid (and into the vitreous chamber), were the following :—

The retina appeared semiopaque ; the outer surface was sprinkled with colloid globules, blood spots, granules of lime, and patches of hexagonal cells. In the retina near the surfaces were numerous groups of brown and grey pigment molecules, many of which were enclosed within shrivelled vessels.

The vitreous substance may become fluid but remain transparent ; or the portion within the area of the ora serrata may retain its normal consistence ; while that in the area of the retina becomes fluid, as has been observed in some myopic eyes. Fibrous, cartilaginous, and connective tissue are frequently developed in the vitreous chamber after acute inflammation. In several eyes (removed during life) with partial displacement of the retina, the vitreous substance, immediately adjoining the displaced retina, was more or less fluid with opaque filaments, shreads, membranes, or large portions of the hyaloid membrane floating in it.

The fluid occupying the space between choroid and displaced retina is often transparent or yellowish, and always more or less albuminous. Sometimes it is mixed with blood, often with an abundance of granule-corpuscles or with cholesterine crystals (which may be visible through the retina) ; or it is traversed by bands of fibrin, or of connective tissue, extending from the inner surface of the choroid to the outer surface of the retina.

Lime particles, lying loosely upon, or attached to the choroid, plates of bone of varying thickness, and colloid formations, are the products most frequently found upon the inner (retinal) surface of the choroid.

Vision.

Displacement of the retina, if it commence without pain or outward inflammation, may escape notice for some time, until the patient accidentally discovers that sight is failing. Some patients state that when the eye began to fail they suddenly found they could only see the halves of objects, or that a black, well-defined cloud (sometimes appearing at first red, then yellow) obscured some, and generally the upper, parts of objects. Objects at the outset of the displacement often appear crooked, bent, or multiplied, or as if surrounded by red haze. These changes, in many cases, especially if following an injury of the tunics of the ciliary region, may be preceded for years by muscæ, or by some "dimness." In some cases the muscæ appear suddenly, and the displacement shortly follows.

Severe throbbing pain in the eye and temple, fiery circles, stars suddenly appearing and disappearing, may precede the displacement for weeks. Some patients state that, after bodily exertion, a flash of light passing across the eye has been followed by sudden impairment of vision.

Owing to changes in the retina adjoining the displaced portions, the

impairment of vision is often more considerable than might be expected from the extent of the displacement, especially in fresh cases. The transition from the blind to the normal parts of the retina is gradual if the displacement is small; it is sudden if large portions of retina are displaced.

The greater part of the retina may be displaced, and the patient may still be able to read small type, if the region of the yellow spot has remained intact; or all perception of objects may be abolished if the retina round the optic disc has been displaced, though there still be a large excentric portion in its proper position. The upper or the lower parts only of an object are perceived if the upper or lower half of the retina is alone displaced. In a few cases of complete displacement of the retina the power of perceiving light has been retained.

Secondary changes often destroy the sensibility of portions of retina which are not displaced.

Vision may become much improved after the changes in the retina next to the displaced portion and those in the vitreous chamber have subsided. The fluid between retina and choroid often becomes less, or alters its position; and the sensitive parts of the retina are thus excluded from vision. It not unfrequently happens that the displacement is complicated with effusion of blood into the vitreous chamber, or with cataract; in such cases the retina may not be accessible to ophthalmoscopic examination.

Cataract generally appears two or three years after displacement of a considerable portion (generally the lower half) of the retina: it is particularly necessary in such cases to recognize the presence of displacement by testing the sensibility of the retina. For this purpose the patient is placed in a dark room. The healthy eye being kept closed, the flame of a candle is moved before the suspected eye or reflected upon it with the ophthalmoscope. The flame can be perceived only by sensitive portions of the retina. Suppose the lower half of the retina to be displaced, we shall find that if the flame be held opposite to it (that is, above the level of the pupil) the patient cannot perceive the flame; and if requested to indicate with his hand the position of the flame, he cannot do so. In cases of cataract this is conclusive. In effusion of blood into the vitreous chamber a doubt remains as long as the blood is accumulated at the most depending part, thus preventing the light from reaching the retina.

Treatment.

Spontaneous "absorption" of the fluid between retina and choroid (in part or in toto) has frequently been observed. This occurs sometimes with unusual rapidity. The retina comes again in contact with the choroid, but does not resume its functions. If the displacement is limited, and the displaced retina transparent, or nearly so, and the patient is otherwise in good health, from six to twelve leeches should be applied to the temple of the

affected side at bedtime; after which both eyes must be kept closed for two or three days, and the patient must remain in bed. The improvement in some cases is very great after repeated leeching. Patients with bare perception of shadows have been able, after the second leeching, to read large letters. In some, however, effusion of blood has occurred between the choroid and retina after the leeching; in others no improvement has followed.

No treatment restores even perception of light if the entire retina is displaced.

The local application of atropia, though it may not effect improvement of vision, seems to retard further displacement. Atropia should be used sufficiently frequently to keep the ciliary muscle of the affected eye at rest.

No treatment seems of use—

(1.) If the entire retina is displaced, or if the displaced retina has lost its transparency, or if there exists atrophy of the rest of the retina and of the optic disc.

(2.) If the displacement has occurred in the course of ophthalmitis, or of suppuration of the retina, or if suppuration of the vitreous substance within the area of the retina has set in.

(3.) If the displacement is a complication of intra-ocular tumours.

In the two latter cases excision of the eyeball may have to be performed.

Myopic persons are the only subjects in whom the displacement has hitherto been observed in both eyes. It is in myopics that photopsia and hæmorrhage into the vitreous chamber most frequently precede the displacement. A diffused red colour appearing suddenly in the interior of a myopic eye (viewed with the ophthalmoscope), so that no distinct view can be obtained of the optic disc and of the tunics, has been observed as a symptom of commencing displacement ("of loosening") of the retina.

The displaced retina occasionally becomes ruptured spontaneously, and the fluid between it and the choroid escapes into the vitreous chamber, while the retina resumes its position upon the choroid. This has led to the operation of perforating the displaced retina. No serious accidents have followed in the cases hitherto operated upon.

The earlier the operation is performed the greater is the improvement of vision that may be obtained. This, sometimes, is almost immediate, or appears a few days later.

Signs of the success of the operation are:—disappearing or diminution of the displacement; turbidity of the previously transparent vitreous substance; improved sensibility of the peripheral parts of the retina. Immediately before performing the operation we should ascertain the degree of impairment of vision, and the extent and position of the displacement.

Operation.

The patient is seated as for ophthalmoscopic examination; the eyelids are kept open by the wire speculum; and the eyeball is fixed by an assistant. The operator uses the ophthalmoscope with the left hand; and having, by "direct" examination, obtained a view of the prominent portion of the displaced retina, thrusts a cataract needle of sufficient length through the tunics into the vitreous chamber at the spot which seems most suitable. The operator watches with the ophthalmoscope the passage of the needle across the vitreous chamber and through the displaced retina into the space between it and the choroid. Having thrust the needle through the displaced retina, he gives the ophthalmoscope to an assistant, who, with it, throws light upon the eyeball. The operator then passes through the tunics a second needle, about the third of an inch from the first one, carrying it as nearly as possible to the spot where the first one has passed through the displaced retina. After having brought the second needle in contact with the first, the operator thrusts the former on still a little further (about to the same extent as the first needle). The points of the two needles are now supposed to be in the space between the choroid and displaced retina, their stems crossing each other.

The object of the next manœuvre is to tear a hole in the displaced retina. This is accomplished by approaching the handles of the needles towards each other (without withdrawing them or pushing them further into the eye, and without making the movements so extensive as to cause the points to touch the portion of the retina not displaced). Having manipulated with the needles in such a manner as to make the existence of a rent in the displaced retina probable, one needle is withdrawn, and the ophthalmoscope is again used, to ascertain, if possible, the effect of the operation.

If the previously transparent vitreous substance is now turbid, or a rent is visible in the retina, or if flocculi of retina are seen projecting from the displaced portion, the second needle is also withdrawn. The manipulation with the two needles should be repeated if no alteration has occurred in the appearance of the displaced retina. The patient is put to bed, and the eyelids of both eyes are kept closed for a few days. Experience, as regards the kind of cases in which the operation should be recommended, and the final results, is too limited to enable us to establish any rules.

The prognosis of displaced retina is, under all circumstances, very gloomy, and justifies our recommending an operative treatment, which, in several of the cases in which it has been adopted, has had favourable results.

An eye with displacement of a small portion of the retina between the yellow spot and the optic disc, and with divergent strabismus, was operated

upon for the strabismus. A few weeks after the operation the vessels in the displaced portion of the retina resumed their natural course, and vision became much improved.

AMBLYOPIA, OR AMAUROSIS, WITH APPARENTLY HEALTHY OPTIC DISC.

Cases of sudden loss, or of rapid impairment of vision, if examined with the ophthalmoscope soon after the impairment or loss of vision has occurred, often present no perceptible changes as regards the optic disc.

As causes of such loss of vision have been observed cerebral apoplexy;—echinococcus in one of the hemispheres;—hæmorrhage from the stomach or uterus;—general impairment of nutrition;—neuralgia in the face or eye;—periostitis of the facial bones;—inflammations accompanying "carious" teeth.

If confined to one eye, anæmia of the retina may be observed in the affected eye. In some cases it is difficult, even for an experienced observer, to decide whether an optic disc is normal as regards colour, or unduly hyperæmic, or slightly anæmic, &c. An intimate acquaintance with the different shades of colour observed in health, at different ages and in eyes of different colour, must assist us in the diagnosis.

The prognosis is uncertain as long as the optic disc retains its natural pink colour.

Such cases have been described as cases of reflex amblyopia, or of reflex amaurosis, if no morbid changes have been visible in the retina and in the optic disc.

The treatment, in great measure, depends upon the nature of other symptoms. The division of a nerve which may be the source of spasm or of neuralgia, the removal of a carious tooth, complete exclusion from light for some weeks, general medical treatment adapted to the patient's constitution, &c., have in many cases rapidly succeeded in restoring or improving vision.

HYPERÆMIA OF THE OPTIC DISC. See Plate V. Fig. 1; Plate VII. fig. 15.

The characteristic symptom of hyperæmia of the optic disc is redness or undue capillary vascularity of its connective tissue. The highly hyperæmic optic disc of fair eyes often appears as red as the adjoining choroid. The outline of the disc, as regards colour, may thus appear effaced, and sometimes can only be recognized by the retinal blood-vessels, which radiate from the spot occupied by the disc.

Hyperæmia of the optic disc, even to an extreme degree, may coexist with anæmia of the retina, as is observed in one form of syphilitic choroido-retinitis. The hyperæmia may occur with normal vascularity of the retina, as in cases where the hyperæmia precedes atrophy of the optic nerve, e.g. in persons suffering from the effects of tobacco.

Hyperæmia of the optic disc and of the retina, with an increase in the number of arteries and veins, and often with venous pulsation, precedes and accompanies retinitis situated at some distance from the disc.

If inflammation of the optic disc and of the adjoining retina threatens, we find the retinal arteries generally fewer in number, while the veins in the retina and optic disc appear large and tortuous.

ANÆMIA OF THE OPTIC DISC ("The white od"). See Plate VI. Fig. 7.

A more or less marked diminution of the natural pink colour of the optic disc causes the disc, when viewed with the ophthalmoscope, to appear pearly-white in the centre (where it is free from optic nerve fibres), while the rest of the disc has a greyish or bluish-white and opaque colour.

We can, by direct ophthalmoscopic examination, ascertain the presence of the layer of optic nerve fibres, where it passes from the disc on to the retina. That layer gives to the margin of the optic disc a slightly-striated hazy appearance.

The optic disc may remain anæmic for years without its nerve fibres, when examined microscopically, appearing altered.

Of late the term "White Atrophy" has been applied to every white optic disc.

The optic disc, deprived of blood, always appears white or bluish-white, this being the natural colour of the connective tissue in the sclerotic aperture. The optic nerve fibres, when atrophic, do not become white, but simply disappear. The only certain sign of atrophy is the absence, or decrease in number, of the optic nerve fibres. The contrast between the colour of the choroid and that of the optic disc causes the latter to appear well-defined, unless there are atrophic transparent spots of choroid adjoining it; or unless the sclerotic margin of the optic disc is exposed. On superficial ophthalmoscopic examination, the disc may appear too large or irregular in shape; while, on careful direct ophthalmoscopic examination, its outline and size can be readily recognized.

The portion of the disc next the yellow spot is that which frequently becomes anæmic first. In a case of tumour, occupying the right side of the base of the brain, anæmia of the outer half of the right optic disc established itself within twelve weeks with paralysis of the corresponding

retina. Three weeks later the entire disc appeared anæmic, and the entire retina was found paralysed.

In anæmia of the optic disc and retina the vessels of the retina (arteries and veins) are thin; but as regards number normal; while in atrophy the arteries are often barely perceptible, always fewer in number, and much thinner than the veins.

As causes of anæmia have been observed general anæmia;—excessive loss of blood, e.g. during parturition;—rapid increase of tumours, &c.

INFLAMMATION OF THE OPTIC DISC, AND OF THE RETINA IMMEDIATELY ADJOINING IT. See Plate VII. Fig. 16; Plate X. Fig. 36.

Venous hyperæmia of the optic disc and retina having continued for some time, the optic disc and the retina become greyish and semiopaque. The opaque portions often occupy an area of from two to three times the size of the optic disc. This change appears frequently in both eyes, but varies in degree.

The opaque portion of retina obscures the choroid, and with it the outline of the optic disc.

The exact spot occupied by the disc sometimes cannot be found if no blood-vessels are visible; while, if they have not completely disappeared in the opaque parts, we may infer the position of the disc from their convergence towards it.

The veins in the transparent retina appear dark red, tortuous, gorged, and, together with the arteries, disappear more or less in the opaque parts. Blood spots of varying size often appear by the sides of the enlarged veins.

Fulness of the vessels of the orbit, with some protrusion of the eyeball, is met with occasionally. For the further changes in colour of the optic disc and of the retina, see Retinitis, and Atrophy of the Retina and of the Optic Disc.

As causes of inflammation of one of the optic discs, or of both, have been observed—disease in the orbit;—tumours;—erysipelatous or other inflammation;—inflammation of Tenon's capsule;—and inter-cranial changes, causing pressure upon, or overfulness of, the cavernous sinuses.

Inflammation of both optic discs occurs in the course of syphilis;—cerebral fibro-plastic tumour;—albuminuria;—and embolism. It is accompanied by extensive retinitis, except when connected with cerebral tumour.

We must pay particular attention to the state of the brain, kidneys, and arteries whenever we find the optic discs inflamed.

Vision.

Vision, according to the accounts given by patients, is often hardly

disturbed, even if there is considerable loss of transparency of the optic disc and of the adjoining retina, with much hyperæmia.

The conveyance of impressions from the yellow spot and other parts of the retina appears in such cases to be but little impeded. The extra-ocular cause, which may have given rise to these changes, may reduce vision much more than can be explained by the changes visible with the ophthalmoscope.

Some patients (even at the height of the inflammation) only complain of a swimming of objects looked at for some time.

Photopsiæ and chromopsiæ are frequently, but pain is hardly ever, complained of.

For Treatment, see Retinitis.

THE SWOLLEN, PROMINENT, ILL-DEFINED OPTIC DISC.

See Plate VI. Fig. 9.

Inflammation of the Optic Disc. Neuritis Optica.

The term Neuritis optica is also applied to inflammation of the trunk of the optic nerve in any part of its extra-ocular course.

The inflammation has hitherto always been observed in both eyes, and usually first in the left eye.

Vision.

Patients frequently complain at first of distortion of the outlines of objects, followed by a "mist." The latter appears rather suddenly between objects looked at and the eyes, and rapidly becomes thicker, reducing vision, sometimes within a few days, to mere perception of light.

The sensibility of the region of the yellow spot generally decreases more rapidly than that of the rest of the retina.

In a case of "fibro-plastic" tumour at the chiasma the inner half of each retina was paralysed.

In a case of inflammation of both optic discs the centre and inner half of the right, and the inner half of the left, retina remained sensitive and improved under treatment; while the blind parts did not recover.

Destruction of the optic nerve fibres, impaired nutrition of the retina, and atrophy of these parts, seem to be the chief causes of permanently impaired vision.

Neuritis (inflammation) of the optic disc is in itself not painful. Photopsia, chromopsia, and photophobia are symptoms which, though frequently observed, may be entirely missing. Pain in the head, which may be very severe, often ceases completely when vision is lost.

Changes observed with the Ophthalmoscope.

In the centre of Plate VI. Fig. 9, is represented the appearance of the swollen optic disc during the height of inflammation. The optic disc gradually becomes anæmic and more or less atrophic.

The stage represented in Plate VI. Fig. 9 is preceded by increased redness of the optic disc. The disc gradually assumes a greyish-red or lilac colour, loses its defined outline, and shades off into the adjoining tunics. This change sometimes appears simultaneously in the entire disc; in other cases one half of the disc becomes altered first; this may be accompanied by paralysis of the corresponding half of the retina. In slight cases the centre of the disc remains red, while in severe inflammation the entire disc becomes grey and opaque. The change in colour and outline is accompanied by considerable swelling of the disc, as may be ascertained by direct ophthalmoscopic examination.

The retinal arteries in the disc and in the retina are unusually thin. In severe cases neither arteries nor veins are perceptible in the disc. The retinal veins in the retina are large, tortuous, sometimes numerous, sometimes but few, according to the rapidity with which the circulation becomes impeded at the optic disc. They are more or less hidden from view where they pass from the transparent into the turbid, swollen parts of the disc. Some may be seen climbing from the retina over the swollen prominent part of the disc towards its somewhat depressed centre. Blood spots in the disc are the exception.

The tunics (retina, &c.) immediately adjoining the disc lose their transparency during the height of the inflammation; they assume a greyish semiopaque colour which, as represented in Plate VI. Fig. 9, is confined to the very margin of the sclerotic, choroidal, and retinal apertures. This essentially distinguishes pure neuritis from neuro-retinitis (as it occurs during syphilis and albuminuria), and from œdema of the optic disc and retina. In the latter cases a large area of retina and choroid is inflamed, and there is more or less extensive hæmorrhage into the retina.

Occasionally we see few grey and opaque flocculi in the vitreous chamber close to the optic disc.

Anæmia of the choroid, so as to bring into view groups of stellate pigment cells, is frequently observed.

Microscopic examination has shown that the swelling of the optic disc is due to an increase of nuclei and nucleated cells of the connective tissue of the optic disc, and to œdema.

The swelling (the seat of inflammation) has been found confined to the optic discs, or to extra-ocular portions of the nerve, or to the chiasma. Both optic nerves have been found swollen in their entire length, from

the optic discs to the corpora geniculata, where the swelling ceased abruptly.

The swollen optic nerve may appear two or three times its normal size.

Microscopic examination of the white optic disc, after the swelling has disappeared, shows that most or all of the optic nerve fibres have disappeared, leaving atrophic connective tissue with nuclei and débris of pigment.

The pinkish or lilac colour of the optic disc disappears in from six to twenty days. The disc assumes a pearly-white colour and continues swollen for a considerable time. The swelling is gradually followed by flattening and atrophy of the disc, and by atrophy of a narrow rim of the adjoining choroid and retina. The margin of the disc, though well-defined, appears irregular through the choroid having become atrophic, thus bringing the white sclerotic aperture into view.

The arteries of the retina remain thin, or may entirely disappear. The veins in the retina remain tortuous and enlarged for some time after the swelling has subsided.

We distinguish, first, the anæmic, atrophic, ill-defined, frequently oval optic disc with atrophy of the adjoining choroidal and retinal aperture, and anæmia of the retina (the arteries being particularly thin); and, secondly, anæmia, or anæmia and atrophy of the optic disc from extra-ocular causes. In the latter form the choroido-retinal aperture remains unaltered, the optic disc well-defined, and the blood supply to the retina frequently normal.

The former form of atrophy has hitherto always been observed in both eyes. It is often preceded by giddiness, headache, pain at the back of the head, fits, and numbness in the extremities. It is the result of inflammation of the optic discs.

Extensive disease of the brain has been found in all cases in which a post-mortem examination has been made. A fibro-plastic tumour was found encroaching, in four cases, upon the cerebellum; in three upon the hemispheres. In one case softening of the Thalami Optici and Corpora quadrigemina, and in another case softening of the right hemisphere and of the adjoining corpus striatum was observed.

In all cases the cerebral lesion had existed for some time before the inflammation of the optic nerve made its appearance.

Inflammation of other nerves may exist simultaneously, giving rise to symptoms which may assist in localizing the cerebral changes. Such symptoms are—hemiplegia (more frequently on the left side),—facial paralysis,—attacks of giddiness,—"epileptic" fits,—vomiting,—severe pain in the head "from temple to temple,"—occasionally impairment of memory,—lesions of locomotion, of smell, &c.

Treatment.

In several cases much benefit has been derived from the use of mercury. The swelling of the disc has seemed to disappear rapidly; and the amount of vision, existing at the time when the mercury was prescribed, has been preserved. No treatment has been found of use after the swelling has disappeared, and the optic disc has assumed a pearly-white colour.

Large doses of bromide of potassium should be tried if there are fits.

The severe pain in the head is much relieved by a large blister applied to the forehead.

ATROPHY OF THE OPTIC DISC (The white Atrophic Optic Disc).

We distinguish—

(1.) Atrophy following inflammation of the disc. The optic disc, after the inflammation, appears irregular, ill-defined, and white, with anæmia of the retina and with atrophic spots in the choroid immediately adjoining the disc.

(2.) Atrophy through choroido-retinitis implicating the optic disc (see Plate VI. Fig. 11; Plate VII. Fig. 17). The atrophy may remain confined to portions of the disc; and, like the following form, may be accompanied by atrophy of portions of choroid and retina.

(3.) Atrophy following intra-ocular changes (e. g. choroido-retinitis) remote from the disc, causing paralysis or destruction of the retina, and secondarily atrophy of the disc (see Plate VII. Fig. 18; Plate X. Fig. 25). In these cases the atrophy advances from the disc towards the brain.

(4.) Atrophy with cupping of the disc as observed in glaucomatous changes (represented in Plate IX. Fig. 29).

(5.) Atrophy through extra-ocular changes (see Plate VI. Fig. 8).

We shall here treat more particularly of this latter form of atrophy.

The optic disc has a brilliant white or bluish-white colour.

The white rim of sclerotic, and the abrupt, well-defined margin of the vascular choroid which surround the atrophic disc are correctly represented in Plate VI. Fig. 8.

In high degrees of atrophy, where the disc is much shrunken, and its colour more uniform, it is sometimes difficult to trace the boundary between the sclerotic and the disc.

The optic nerve fibres, if atrophy sets in after prolonged anæmia, at first become thinner and finally disappear; their place is sometimes found occupied by rows of black pigment granules, while the surrounding connective tissue appears loaded with nuclei and pigment.

General morbid changes, e. g. those which are the results of poisoning by narcotics, &c., seem to give rise to lesions of the nerve fibres themselves, and to induce atrophy unusually rapidly.

In inflammation of the optic disc considerable swelling of the nerve fibres, as well as of the connective tissue, precedes the atrophy.

The connective tissue in the optic disc, as well as in other parts of the optic nerve, occasionally undergoes a peculiar change of colour, from opaque white into a greyish semiopaque colour.

A decrease in the number and size of the blood-vessels of the retina is observed in all cases. The retina which carries the smallest number of blood-containing vessels is, as a rule, the one which has become impaired first.

Atrophy of the optic disc (nerve) and of the retina appears much sooner if the portion of the optic nerve which encloses the retinal vessels becomes atrophic; or if changes in that part of the nerve impair the influx and efflux of blood; or if morbid changes (embolism, tumours) intercept the blood supply.

A characteristic sign of atrophy of the optic disc and of the retina is a greyish-white and opaque line along either side of each of the larger retinal vessels. These lines are the result of loss of transparency and of thickening of the connective tissue adjoining the vessels; and, together with decrease in the size and number of the blood-vessels, are more conspicuous as regards the arteries.

Sometimes no blood is visible in the arteries, while two or three veins of considerable calibre may still be seen passing through the optic disc.

It is of special importance as regards prognosis and treatment of cases of amblyopia or amaurosis, of which the sole ocular symptom is partial or total anæmia or atrophy of the optic disc, carefully to inquire into the general history of our patient. We should ascertain whether lesions in the functions of other nerves exist, and how far they help in the recognition of the seat and cause of amaurosis. (See Amblyopia and Amaurosis.)

From ophthalmoscopic examination we can learn—

(1.) Whether the tunics (retina, &c.) have their natural transparency.

(2.) Whether the appearance due to the presence of the optic nerve fibres is preserved in the disc and upon the retinal aperture.

(3.) Whether the blood supply to the choroid and retina is sufficient, or whether from the state of the blood-vessels we must assume atrophic changes to have commenced.

If we find the optic disc atrophic, a change which is always accompanied by diminution in the calibre of the retinal blood-vessels, no hope remains as regards the recovery of vision, whatever may be the prospects of removing the cause of the atrophy. If the optic nerve appears merely

anæmic or only atrophic in parts, and the blood supply to the retina sufficient, as may be the case for years, we can, as far as the eye is concerned, hold out hopes of regaining vision.

As regards the extra-ocular causes of anæmia and atrophy of the optic disc, and of the optic nerve outside the eye, it must be borne in mind *that every change outside the eye which produces loss of sight is gradually followed by anæmia of the optic disc, and often sooner or later by atrophy.*

If, therefore, as stated above, we meet with amaurosis or amblyopia, the sole ocular symptom of which is "a white" or "a white and atrophic optic disc," we must seek information as regards cause, prognosis, and treatment, not with the ophthalmoscope only. We must ascertain the state of the functions of the brain and of the nervous system, and whether any lesions or general morbid changes can be found which are known primarily or secondarily to affect vision. These points are treated of under Amaurosis and Amblyopia.

Vision.

The alterations of vision observed in the course of anæmia and of atrophy of the optic disc present numerous varieties and degrees of impairment. For practical purposes we distinguish the sudden, the rapid, and the gradual loss of vision, which may occur in both, in one, or only in portions of one eye.

Sudden complete loss of vision of both eyes is observed in changes implicating the corpora quadrigemina and thalami optici.

Effusion of blood from ruptured blood-vessels, whether spontaneous, or during vomiting, or from injury, or through embolism, is the most frequent cause.

Sudden complete loss of vision of one eye only, from the same cause, is often followed by impairment and by comparatively rapid loss of vision of the fellow eye (within one or two months). Injuries, or tumours implicating one foramen opticum only, have also caused sudden permanent loss of vision of one eye.

Rapid loss or impairment of vision, within from twenty-four hours to a few days, has been observed in the course of tumours,—of inflammation of different parts of the optic nerves,—of different forms of inflammation of the brain and of its coverings. The loss or impairment of vision may, as a rule, be attributed to past inflammation of the optic disc, if it has been preceded by vomiting, headache, and fits, and if, with the ophthalmoscope, we find the choroidal margin of the white optic disc ill-defined and pigmented.

Gradual loss of vision, extending over months and years, is observed in cases of poisoning with lead, arsenic, tobacco, &c., and in disease of the hemispheres.

The impairment of vision in most cases announces itself by a mist appearing to intervene between objects looked at and the eye. The mist gradually becomes thicker, so that large distant or small near objects are no longer recognized. Some patients state that the mist has advanced "from one part of the eye," and gradually extended over the rest; others find that by holding objects sideways they see them better; while in others the peripheral parts of the retina are comparatively more impaired.

Some complain of difficulty in recognizing objects when coming from a light into a somewhat darker room.

Flickering or trembling of objects, previous to the appearance of the mist, has been noticed in cerebral tumours.

Photopsia and chromopsia may appear at any stage, and after all perception of light is lost.

Treatment.

To decide upon the line of treatment in a case of amblyopia or amaurosis with anæmia or atrophy of the optic disc, we first ascertain the cause. The cause may be intra-ocular, or extra-ocular; the extra-ocular cause may be orbital, or extra-orbital. We shall here enter only into the treatment of anæmia or atrophy of the optic disc from extra-ocular causes. The treatment connected with intra-ocular causes will be found under the different morbid changes of the tunics of the eyeball, which may lead to destruction of the optic nerve fibres in the eye.

Among extra-ocular causes we distinguish those situated within the orbit: such are inflammation, injuries, tumours; in these the atrophy of the optic nerve is often confined to one eye. (See "Orbit.") Other extra-ocular causes are those which are grouped together as cerebral causes. Whatever directly or indirectly induces destruction of the optic nerve fibres within the cranial cavity gives rise to amblyopia or amaurosis. These conditions, if they have existed for some time, are followed by anæmia, with or without atrophy of the optic disc and retina.

Our treatment has to bear upon the cerebral changes, and belongs to the domain of general medicine.

In the diagnosis as to the seat and nature of the cerebral lesion we are guided by what has been said under Amblyopia, Amaurosis; and by our knowledge regarding the course of the optic nerve fibres within the cranium, and their relation to other parts of the nervous and vascular system, and to the walls of the cranium.

THE CUPPED OPTIC DISC. Excavation, or Cupping of the Optic Disc. See Plate IX. Figs. 27, 29.

Abnormal curvature of the surface of the optic disc is of frequent occur-

rence. It differs from the cup observed in health by the part of the optic disc, which is occupied by nerve fibres, becoming cupped, and by the course and appearance of the retinal blood-vessels, especially of the veins becoming altered. The alteration alone of the course of these vessels furnishes the proof of the cup being the result of morbid changes.

To diagnose the existence of cupped optic disc, if no vessels are visible in the disc (as in hæmorrhage into the cup, or in extreme glaucomatous atrophy of the disc), requires much experience in direct ophthalmoscopic examination; while the presence of retinal vessels filled with blood renders the recognition of the cupped disc easy.

Destruction of the optic nerve fibres in the optic disc, whether from pressure or from atrophy, or from both, with or without preservation of their connective tissue, gives rise to a cupped anæmic condition of the disc.

The margin of the cup is formed by the margins of the retina and choroid, but more frequently only by the inner edge of the sclerotic aperture; the sides of the cup are made up partly of sclerotic, and partly of the nerve adjoining the sclerotic.

Vitreous substance or fluid occupies the cavity of the cup.

The veins of the retina, on reaching the margin of the cupped optic disc (to arrive at their point of exit from the eye), have to wind round the margin of the cup and to creep along its sides. This margin often considerably overlaps the rest of the cup (throwing a bluish-white crescentic shadow, which shifts its place if we alter the direction from which light is thrown into the cup by the ophthalmoscope). The veins, which come from the retina, after having wound round this margin, disappear behind it. If it be very prominent, a portion of each vein is hidden. The veins become visible again in the part of the cup which is not excluded from view by the margin. The winding course of the retinal veins is accompanied by an alteration in their width (properly speaking, in the quantity of blood carried by them). The veins in the retina appear full and often tortuous. Exactly at the margin of the disc, and, if much increase of tension exists, also on the white rim of sclerotic adjoining it, and in the generally greyish-white disc itself, the veins appear thin and nearly empty.

The vessels in the cup in rare cases, after removal of undue tension, become full and varicose.

It is essential to distinguish—

(1.) The cupped optic disc, which is the result of undue (glaucomatous) tension, and

(2.) The cupped optic disc, caused by pure atrophy.

The former is described under Glaucoma, and is deep, with its margins abrupt and generally projecting over the cavity of the cup. The deviation in the course of the veins and the increase of tension are well marked. The cupping is, as a rule, most considerable on the portion of the disc next

the yellow spot. In myopic eyes the cup may be confined to that part.

The cupped optic disc, when the result of pure atrophy of the optic nerve fibres, is uniformly white. Its margin is not abrupt, even if the cup is deep. It is usually shallow, and the deepest part occupies the middle of the optic disc. The displacement and the bending of the vessels is feeble. The veins are not suddenly interrupted at the margin; they are almost as thin in the cup as in the retina.

Atrophy of the optic nerve fibres from intra or extra-ocular causes (but not from glaucoma), is the cause of this kind of cup. On dissection we find the walls of the cup occupied by connective tissue and by numerous nuclei.

When stating that the optic disc is cupped, it is essential to mention, whether the cup is the result of undue tension of the eyeball, or of pure atrophy, or of both.

THE END.

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